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No. OFFICE OF THE CLERK

In the Supreme Court of the United States

OCTOBER TERM, 1996

UNITED STATES OF AMERICA, PETITIONER

v.

HUGHES AIRCRAFT COMPANY

ON PETITION FOR A WRIT OF CERTIORARI TO THE UNITED STATES COURT OF APPEALS FOR THE FEDERAL CIRCUIT

APPENDIX TO PETITION FOR A WRIT OF CERTIORARI

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APPENDIX A

UNITED STATES COURT OF APPEALS
FOR THE FEDRAL CIRCUIT

Nos. 94-5149, 95-5001

HUGHES AIRCRAFT COMPANY,
PLAINTIFF-APPELLANT

v.

THE UNITED STATES,
DEFENDANT/CROSS-APPELLANT

June 19, 1996

Before: ARCHER, Chief Judge, NIES, Senior Circuit Judge,* and BRYSON, Circuit Judge.

Opinion for the court filed by Chief Judge ARCHER. Concurring opinion filed by Circuit Judge BRYSON. Dissenting opinion filed by Senior Circuit Judge NIES.

ARCHER, Chief Judge.

Hughes Aircraft Company (Hughes) appeals the judgment of the United States Court of Federal Claims awarding Hughes compensation based on a 1% royalty rate with respect to spacecraft manufactured and used by or for the United States which embody the invention of Hughes' United States Patent No. 3,758,051 (the Williams patent). *Hughes Aircraft Co.*

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* Judge Nies assumed senior status on November 1, 1995.

v. United States, 31 Fed. Cl. 481, 35 USPQ2d 1243 (1994) (*Hughes XII*).[1] Hughes argues that the 1% royalty rate is too low. The United States cross-appeals contending that certain spacecraft were incorrectly included in the royalty base and that the interest rates used to calculate Hughes' delay damages were too high. We affirm.

BACKGROUND

A. The Williams patent relates to an apparatus for controlling the orientation of the spin axis of spin-stabilized space vehicles such as satellites positioned in orbit around the earth. The patent was issued to Donald Williams on September 11, 1973. To correct orbital deviations, the Williams apparatus applies a reactive force to the satellite by firing a jet so as to "precess," or tip, the satellite into the proper position. Although this technique was known in the prior art,[2] the Williams apparatus was the first to maintain its spin axis with reference to a fixed external coordinate system. *Hughes Aircraft Co. v. United States*, 717 F.2d 1351, 1360, 219 USPQ 473, 479 (Fed.Cir.1983) (*Hughes VII*).

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[1] During this litigation twelve prior opinions have issued. The first eight reported decisions are listed in *Hughes Aircraft Co. v. United States*, 15 Cl.Ct. 550, 551 n. 2, 8 USPQ2d 1989, 1990 n. 2 (1988) (*Hughes IX*), and the tenth through twelfth are referenced in *Hughes XII*, 31 Fed. Cl. at 483 n. 2, 35 USPQ2d at 1244 n. 2. This ordering is used herein to number the *Hughes* opinions cited repeatedly. Two other decisions involving the Williams patent are listed in *Hughes IX*, 15 Cl.Ct. at 551 n. 2, 8 USPQ2d at 1990 n. 2.

[2] The McLean patent (United States Patent No. 3,216,674) was the first to disclose the basic concept of pulsing a jet to correct the spin axis of a satellite, and the government had a non-exclusive license to use it.

The present suit began in 1973 when Hughes brought a claim under 28 U.S.C. § 1498 against the United States for just compensation stemming from the use and manufacture by or for the government of spacecraft embodying the invention claimed in the Williams patent. During the course of the protracted litigation that followed, it was determined by the Court of Federal Claims that Hughes is entitled to just compensation with respect to 81 spacecraft. *Hughes Aircraft Co. v. United States*, 29 Fed. Cl. 197, 243-48, 29 USPQ2d 1974, 2010 (1993) (*Hughes X*). The court arrived at the final list of 81 spacecraft based in part on the 1983 decision of this court that certain accused spacecraft that use the "store and execute" method for controlling the precession jet infringe the claims of the Williams patent under the doctrine of equivalents. *Hughes VII*, 717 F.2d at 1366, 219 USPQ at 484. The Court of Federal Claims then found the value of the compensation base for calculating Hughes' award to be $3.577 billion, which was arrived at by using "total spacecraft cost," *i.e.*, the total procurement cost, including payload costs, to the government of the 81 spacecraft. *Hughes Aircraft Co. v. United States*, 31 Fed. Cl. 464, 468 n. 5, 477 (1994) (*Hughes XI*).

In *Hughes XII*, the Court of Federal Claims considered only the calculation of the amount of Hughes' award. The court first determined what royalty rate to apply to the compensation base to provide Hughes a reasonable royalty for the government's use of the patented invention. The court then considered the amount of pre-judgment interest (sometimes called "delay damages"), which together with the reasonable royalty would provide "reasonable and entire compensation." *Hughes XII*, 31 Fed.Cl. at 483, 35 USPQ2d at

1251. Because an established royalty rate did not exist for licensing the Williams patent, the court determined the royalty rate using the "willing buyer/willing seller" rule. *Id.* at 484, 35 USPQ2d at 1245. Under this rule, a reasonable royalty is set at the rate that the court determines a "willing licensor and licensee would bargain for at hypothetical negotiations on the date infringement started." *State Indus. v. Mor-Flo Indus.*, 883 F.2d 1573, 1580, 12 USPQ2d 1026, 1031 (Fed.Cir.1989).

The court's royalty rate analysis focused initially on three letters containing acceptable license terms that Hughes had sent to other aerospace companies during the period from 1974 to 1978, none of which resulted in a licensing agreement. The first was a July 1974 letter from Hughes to the Philco-Ford Corporation (Philco-Ford) offering to license the Williams patent and the McLean patent together for 5%, or separately for 3%, of "the sales price of the satellite calculated at the time it is delivered to the launch pad." *Hughes XII*, 31 Fed. Cl. at 486, 35 USPQ2d at 1246. Although Hughes' letter was sent while a suit was pending against Philco-Ford in which Hughes accused Philco-Ford of infringing the Williams patent, the court found nothing in the letter to suggest that the offer was part of a proposed settlement of the litigation and found that the letter was sent by Hughes merely in response to earlier requests by Philco-Ford for terms at which any licenses had been offered to parties unrelated to the suit. *Id.* at 486, 35 USPQ2d at 1247.

The second letter relied on by the court was sent by Hughes to TRW, Inc. (TRW) in September of 1974 and offered a license at the identical rate described in the letter to Philco-Ford. *Id.* at 486, 35 USPQ2d at 1247.

The court noted that there had never been any litigation or threat of litigation between Hughes and TRW relating to the Williams patent. *Id.* at 486, 35 USPQ2d at 1247. With regard to the TRW and Philco-Ford letters, the court found it significant that the anticipated royalty base underlying those offers was smaller than the royalty base in this case. *Id.* at 487, 35 USPQ2d at 1247.

The third letter was sent by Hughes to Messerschmitt-Bolkow-Blohm (MBB), a German corporation, as part of a series of letters regarding settlement of claims by Hughes against MBB. *Id.* at 487, 35 USPQ2d at 1247. As such, the court recognized that this letter could not fairly be considered an ordinary proposal of licensing terms. *Id.* at 487, 35 USPQ2d at 1247. The court instead relied on language in the letter in which Hughes stated that its "normal royalty rate" for licensing the Williams and McLean patents together was 5% of the "full contact price" for a commercial spacecraft or 2% of the "full contract price" for a scientific or experimental spacecraft, with the provision that the cost of scientific or experimental spacecraft did not include the cost of scientific or experimental payloads provided to MBB by others. *Id.* at 487, 35 USPQ2d at 1247. The court found that all of the 81 spacecraft in the royalty base were "scientific or experimental vehicles." *Id.* at 487, 35 USPQ2d at 1247. As Hughes had done in its Ford-Philco and TRW letters, the court reduced the 2% rate quoted in the MBB letter for both the Williams and McLean patents by a factor of 40% to arrive at a 1.2% rate for licensing only the Williams patent for scientific or experimental vehicles. *Id.* at 487, 35 USPQ2d at 1247.

Based on the three offers, the Court of Federal Claims reasoned that negotiations would start at a rate of something less than 1.2% and that the negotiated rates would not fall below the 1% rate the government conceded would result in just compensation. *Id.* at 488, 35 USPQ2d at 1248. According to the court, the royalty rate would "quickly settle on one percent." *Id.* at 488, 35 USPQ2d at 1248. As additional support for the 1% royalty rate, the court pointed to the large size of the royalty base in this case. The court said that "[i]t is axiomatic that the larger the potential compensation base to which a royalty rate will be applied, the lower will be the rate." *Id.* at 488, 35 USPQ2d at 1248-49. The court also noted that Williams was not a "pioneer" invention, that the license taken by the government was non-exclusive and unaccompanied by know-how, that the Hughes license offers to the aerospace companies were not accepted, and that Hughes had an incentive to discourage the development of alternative technology and encourage the use of the Williams invention. *Id.* at 488-89, 35 USPQ2d at 1249-50. As to this last factor the court found that alternatives to the Williams invention existed in 1973 or were soon after developed. *Id.* at 489-90, 35 USPQ2d at 1250. Based on all of these factors, the court determined that a royalty rate of 1% would be reasonable.

The Court of Federal Claims next considered the appropriate interest rate to use in calculating the delay damages to be awarded Hughes because royalties were not currently paid. The court viewed delay damages as necessary to place Hughes in the position that it would have been had the royalties been paid timely and invested in a prudent and reasonable manner. *Id.* at 492, 35 USPQ2d at 1251-52. For the period

from September 11, 1973 to February 1, 1980, the court used rates which it viewed as required by or adopted in prior decisions for the years in question, citing *Tektronix, Inc. v. United States*, 213 Ct.Cl. 257, 552 F.2d 343, 193 USPQ 385 (1977), *Miller v. United States*, 223 Ct.Cl. 352, 620 F.2d 812 (1980), and *Bendix Corp. v. United States*, 230 Ct.Cl. 247, 676 F.2d 606 (1982). Specifically, it used a rate of 7.5% for the period up to 1975 and a rate of 8.5% for the period from 1976 to February 1, 1980. *Hughes XII*, 31 Fed. Cl. at 492-93, 35 USPQ2d at 1252-53. For the remainder of the period of delay, the court applied the relevant tax overpayment rate as prescribed in 26 U.S.C. § 6621, which was defined as 2% above the federal short term rate determined by the Secretary of the Treasury. The court found the tax overpayment rates to be fair, easily ascertainable, commercially reasonable, and objective, with the federal short term rate reflecting the short-term financial market and the 2% additional margin taking into account the fact that long term investments generally earn higher rates. *Id.* at 494, 35 USPQ2d at 1253-54. The court held that the delay damages for the period from 1973 to 1980 should be compounded annually and for the period after February 1, 1980 should be compounded daily as provided for in the tax overpayment compounding provision, 26 U.S.C. § 6622(a). *Id.* at 493, 494-95, 35 USPQ2d at 1253, 1254.

B. In this appeal Hughes puts forth several grounds for reversing the Court of Federal Claims' decision that its compensation should be limited to a 1% royalty rate. Hughes argues that the court erred as a matter of law by treating the rates contained in the letters to Ford-Philco, TRW and MBB as a ceiling on the royalty rate. Also, Hughes asserts that

the rates contained in the letters were artificially low due to widespread infringement of the Williams patent and due to the settlement context in which two of them were sent. Hughes further contends that reliance on the letters was improper because this conflicts with the policy behind Federal Rule of Evidence 408 which in certain circumstances requires the exclusion of evidence of offers made attempting to compromise a disputed claim. Finally, Hughes argues that the determination of the 1% royalty award was based upon three clearly erroneous factual findings. Specifically, Hughes takes issue with the findings that all of the 81 spacecraft determined to be compensable were "scientific or experimental" as that designation was used in the MBB letter, that the royalty base contemplated in the three letters was relatively smaller than the royalty base at issue here, and that during the term of the Williams patent non-infringing substitutes were available. Although it sought a 15% royalty rate before the Court of Federal Claims, Hughes now argues that it is entitled to at least a 3% royalty rate, which it derives from the proffered royalty rate for license of the Williams patent as set forth in two of the letters to the aerospace companies.

The government in its cross-appeal makes two arguments. First, it contends that the delay compensation rates were erroneous as a matter of law because they reflect a risk premium that Hughes did not bear. Moreover, the government says the court erred in failing to account for the annual taxes Hughes would have been required to pay had the royalties been paid currently. Second, the government asserts that Hughes is not entitled to compensation for spacecraft using the "store and execute" method for controlling the precession jet because, despite the

contrary holding in *Hughes VII*, these spacecraft do not infringe the Williams patent. The government asks us to reject *Hughes VII* as law of the case in view of the subsequent holding in *Pennwalt Corp. v. Durand-Wayland, Inc.*, 833 F.2d 931, 4 USPQ2d 1737 (Fed.Cir.1987) (*in banc*), which it suggests is inconsistent with the doctrine of equivalents analysis applied in *Hughes VII*.

DISCUSSION

I.

A. The government's unlicensed use of a patented invention is properly viewed as a taking of property under the Fifth Amendment through the government's exercise of its power of eminent domain and the patent holder's remedy for such use is prescribed by 28 U.S.C. § 1498(a). *Pitcairn v. United States*, 212 Ct.Cl. 168, 547 F.2d 1106, 1114, 192 USPQ 612, 616 (1976); *see also Leesona Corp. v. United States*, 220 Ct.Cl. 234, 599 F.2d 958, 966-67, 202 USPQ 424, 432-33 (1979) (discussing the various ways patent infringement by the government was characterized prior to the enactment of 28 U.S.C. § 1498); *Decca Ltd. v. United States*, 225 Ct.Cl. 326, 640 F.2d 1156, 1166, 209 USPQ 52, 59 (1980). Under section 1498(a), the patent owner is entitled to its "reasonable and entire compensation for such use and manufacture." Because recovery is based on eminent domain, the proper measure is "what the owner has lost, not what the taker has gained." *Leesona*, 599 F.2d at 969, 202 USPQ at 435. Generally, the preferred manner of reasonably and entirely compensating the patent owner is to require the government to pay a reasonable royalty for its license as well as damages for its delay in paying the royalty. *See, e.g., Decca*, 640 F.2d

at 1167-68, 209 USPQ at 60 (discussing the various methods for valuing a patent license taken by the government); *Leesona*, 599 F.2d at 973, 202 USPQ at 438 (same). The parties do not dispute that this is the proper form of compensation; rather, they disagree as to the amount of compensation due and the manner in which it was determined.

Valuation determinations for purposes of eminent domain are reviewed for clear error as are determinations of what constitutes a reasonable royalty. *Whitney Benefits, Inc. v. United States*, 926 F.2d 1169, 1177-78 (Fed.Cir.1991); *Branning v. United States*, 784 F.2d 361, 364 (Fed.Cir.1986); *SmithKline Diagnostics, Inc. v. Helena Lab. Corp.*, 926 F.2d 1161, 1164, 17 USPQ2d 1922, 1925 (Fed.Cir.1991); *Unisplay, S.A. v. American Elec. Sign Co.*, 69 F.3d 512, 517 n. 8, 36 USPQ2d 1540, 1544 n. 8 (Fed.Cir.1995). We will reverse a finding as clearly erroneous only if on the entire evidence we "are left with the definite and firm conviction that a mistake has been committed." *SmithKline*, 926 F.2d at 1164, 17 USPQ2d at 1925 (quoting *United States v. United States Gypsum Co.*, 333 U.S. 364, 395, 68 S.Ct. 525, 542, 92 L.Ed. 746 (1948)). In determining what constitutes a reasonable royalty, the court has discretion to make certain subsidiary decisions, such as what methodology to use to arrive at a reasonable royalty, and those decisions are reviewed for an abuse of discretion. *SmithKline*, 926 F.2d at 1164, 17 USPQ2d at 1925; *Unisplay*, 69 F.3d at 517 n. 8, 36 USPQ2d at 1544 n. 8.

B. Hughes asserts that the Court of Federal Claims held as a matter of law that the rates contained in the letters to Ford-Philco, TRW and MBB established a ceiling to the royalty rate. It contends that this was a legal conclusion, not a factual finding,

and that the court's conclusion is erroneous. The court, however, did not hold as a matter of law that a reasonable royalty can never go above the amount specified in a license offer. Rather, the court analyzed the three letters at issue, as well as other factors, *Hughes XII*, 31 Fed. Cl. 481 at 488-90, 35 USPQ 2d at 1248-50, and found that in this case the rates quoted in the letters had the effect of placing a ceiling on the royalty rate. *See Unisplay*, 69 F.3d at 519, 36 USPQ2d at 1545-46 (holding that a reasonable royalty larger than that contained in license proposals and agreements was not supported by the evidence). Thus, while trying to cast its argument as one attacking a legal conclusion, Hughes is in essence challenging the court's factual findings based on its weighing of the evidence. That, however, is the special province of the trial court and we review such factual findings for clear error. *Inwood Lab., Inc. v. Ives Lab., Inc.*, 456 U.S. 844, 856, 102 S.Ct. 2182, 2189, 72 L.Ed.2d 606 (1982).

Both parties rely on the Court of Claims decision in *Pitcairn* to support their respective positions on whether offers to license a patented invention should or should not be viewed as a ceiling to the reasonable royalty. *Pitcairn*, however, provides no hard and fast rule. *Pitcairn* illustrates that the circumstances surrounding the industry as a whole as well as other relevant factors should be considered to determine what weight to afford an offer to license an invention. The facts of a particular case may call for a reasonable royalty that is more, less or the same as the offered royalty. *See Pitcairn*, 547 F.2d at 1118, 192 USPQ at 618-19 (finding it appropriate under the facts of that case to take into account offers to license a patent when determining a reasonable royalty).

The Court of Federal Claims, as is appropriate, looked at the relevant facts and circumstances at the time when infringement began. As set forth above, the court relied on numerous factors in addition to the Hughes license offers as supporting its finding that hypothetical negotiators would not have agreed to a license at a rate greater than 1.2%. Based on the evidence we are not convinced that the court clearly erred in determining that the ceiling royalty rate in a hypothetical negotiation would be 1.2%.

Hughes also contends that the court clearly erred by failing to take into account the consequence of widespread infringement of the Williams patent. We discern no such failing and are not convinced that any upward adjustment of the court's royalty determination is required for this reason.

The cases cited by Hughes do not, as it argues, support the broad proposition that the court must reject or give very little weight to offers made when there is widespread infringement. Rather these cases stand for the proposition that the entirety of the circumstances should be considered and that the court can consider the effects of infringement. *See, e.g., Sun Studs Inc. v. ATA Equip. Leasing, Inc.*, 872 F.2d 978, 994, 10 USPQ2d 1338, 1351 (Fed.Cir.), *vacated in part*, 872 F.2d 978, 11 USPQ2d 1479 (Fed.Cir.1989), *overruled on other grounds, A.C. Aukerman Co. v. R.L. Chaides Const. Co.*, 960 F.2d 1020, 22 USPQ2d 1321 (Fed.Cir.1992) (stating that a court can take into account the commercial consequences of infringement and need not act as if there had been no infringement); *Deere & Co. v. International Harvester Co.*, 710 F.2d 1551, 1557, 218 USPQ 481, 486 (Fed.Cir.1983) (stating that the district court could discount the probative value of a license negoti-

ated against a backdrop of continuing litigation); *Hanson v. Alpine Valley Ski Area, Inc.*, 718 F.2d 1075, 1078-79, 219 USPQ 679, 682 (Fed.Cir.1983) (stating the trier of fact did not err in rejecting offers to license after infringement had begun as evidence of an established royalty); *Nickson Indus. v. Rol Mfg. Co.*, 847 F.2d 795, 798, 6 USPQ2d 1878, 1880 (Fed.Cir.1988) (stating that a higher royalty "may be awarded when the evidence clearly shows that widespread infringement made the established royalty artificially low").

While we agree that it is appropriate to look at what effect infringement has had on the value of a patent, the court need not consider that in a vacuum. It should take into account other evidence as was done in this case. The court expressly found that at the time of issuance of the Williams patent in 1973 "the space industry was a booming one with prospects for exponential growth" and that "[t]his was the context of Hughes' contacts with three major aerospace firms over the period from 1974 to 1978 in an effort to license the Williams patent." *Hughes XII*, 31 Fed. Cl. at 486, 35 USPQ2d at 1246. The court also considered the context in which the offers were made. It noted that one was made while litigation was pending but as a continuation of earlier licensing negotiations and not in settlement of that claim, that one was made in settlement of claims but contained an indication of "normal" royalty rates and that the other was made while no litigation was pending. In addition, apart from its conclusory statements that infringement must have lowered the rates offered, Hughes has pointed to no evidence showing that the offers in the letters were actually reduced because of widespread infringement. While Hughes points to certain instances of infringement, it does not show that the

license offers were affected by these infringements. In contrast, the court found that one of the letters expressly stated that the proffered royalty rate was Hughes' "normal" rate, not a low rate it was willing to accept because of infringement, thus belying on its face Hughes' contention that the royalty rate was depressed by infringement.

Because the Court of Federal Claims considered the infringement context in which the licensing offers were made as well as other pertinent facts, we are not convinced that the court clearly erred in failing to find that widespread infringement had depressed the indicated royalty rate.

Hughes' claim that the litigation context surrounding the Ford-Philco and MBB letters artificially lowered the rates contained in those letters is intertwined with the foregoing contention. Hughes also argues that those letters were statements made in compromise negotiations and that the court's consideration of them violates the policy behind Federal Rule of Evidence 408. Before the Court of Federal Claims, however, Hughes had no objection to the introduction of these letters and stated that because this case was tried to the court it was sure the letters would "be given the weight they deserve." Unable now to challenge their admissibility, Hughes attacks the weight given these letters by the Court of Federal Claims. We have previously related the court's discussion of the litigation context of these offers, as well as other factors the court considered. Suffice it to say that we discern no clear error in the court's consideration of the Ford-Philco and MBB offers or in its failure to agree with Hughes' contention that the litigation artificially lowered the royalty rates proposed in these license offers.

Hughes also argues that the court's finding that the government's spacecraft were "scientific or experimental" as opposed to "commercial" as those terms were used in the MBB letter is clearly erroneous. After consideration of all the evidence, the court determined that the spacecraft were more akin to scientific and experimental vehicles than commercial vehicles. This finding is supported by the testimony of both parties' experts who each stated that the satellites were experimental and that the government was not in the business of operating satellites for profit. Moreover, Hughes has failed to point to any evidence showing that the spacecraft were being used for commercial purposes, that commercial profit was made, or that any other such indicia of commerciality existed. We therefore cannot say the court clearly erred in finding that the spacecraft should be considered experimental.

Finally, the court did not clearly err in supporting its determination of the royalty rate with the finding that the potential royalty base of the competitors receiving the royalty offers was smaller than the royalty base in this case, which included all spacecraft costs and payload costs, and with the finding that there were acceptable non-infringing alternatives. Hughes' evidence and arguments are insufficient to overturn these findings. Furthermore, these findings were just two out of many that the court used to support its royalty rate determination and Hughes has failed to show that any error associated with these findings would be anything but harmless.

Because the Court of Federal Claims did not clearly err or abuse its discretion in its determination of a reasonable royalty rate, we affirm the 1% royalty rate.

II.

A. The government argues that the interest rates arrived at by the Court of Federal Claims to calculate delay damages overcompensate Hughes for the delay in payment. The government characterizes the royalties owed Hughes as similar to a loan to the government which carries no risk. Under this view, the government argues that the delay damages should be calculated based on the rates paid on Treasury bills. The government criticizes the rates used by the court as improperly including a premium for risk that Hughes did not bear.

A court has discretion in determining the delay compensation rate. *See Pitcairn*, 547 F.2d at 1122, 192 USPQ at 622 ("The determination of a proper amount of delay compensation is a judicial function. The discharge of that function requires the exercise of judgment."). In *Pitcairn*, the Court of Claims approved the use of long-term corporate bond yields as a measure of delay damages because they indicate broad trends and relative levels of investment yields and reflect the amount that the patentee has lost. 547 F.2d at 1122, 1124, 192 USPQ at 622, 624. It then held in *Tektronix* that the 7.5% rate it found applicable for 1975 in *Pitcairn* "should be applied (from now on) to just compensation cases, without need of proof in the individual instance, unless and until it is affirmatively demonstrated that under the theory of the *Pitcairn* opinion the rate for years after 1975 should differ from [that rate]." 552 F.2d at 352, 193 USPQ at 394. The *Pitcairn* analysis was applied in *Miller* to determine that a rate of 8.5% would be appropriate in a land takings case for the years 1976 to 1979, 620 F.2d at 840, and in *Bendix*, to determine that the tax

overpayment rates were appropriate for the period from January 1, 1980 to the date of judgment in that case, 676 F.2d at 615-16. The Court of Federal Claims did not abuse its discretion in adopting these rates for the applicable periods.

The government also argues that the methodology used by the court for calculating delay damages over-compensates Hughes by failing take into account the taxes Hughes would have paid in the years that royalty compensation was due. Expressing concerns about double taxation, the Supreme Court in *Hanover Shoe v. United Shoe Mach. Corp.*, 392 U.S. 481, 503, 88 S.Ct. 2224, 2237, 20 L.Ed.2d 1231 (1968), held that courts do not have to reduce a damage award by the amount of taxes that would have to be paid. This court has applied that rationale in other cases, *see Kalman v. Berlyn Corp.*, 914 F.2d 1473, 1482-83, 16 USPQ2d 1093, 1100 (Fed.Cir.1990), and it is equally applicable to delay damages.

In this case the Court of Federal Claims rejected the government's argument that damages should be reduced by prior years' taxes. It determined that such a reduction (1) had been rejected by the case law; (2) would be speculative due to Hughes' particular tax situation, including what actions Hughes might have taken to reduce such taxes in prior years; and (3) was not provided for by Congress in the tax overpayment provisions. The court did not abuse its discretion in reaching this conclusion.

Finally, the government challenges the court's award of compound rather than simple interest. It is well settled that the determination whether to award simple or compound interest is a matter largely within the discretion of the trial court. *Rite-Hite Corp. v. Kelley Co.*, 56 F.3d 1538, 1555, 35 USPQ2d

1065, 1077 (Fed.Cir.1995) (*in banc*); accord *City of Milwaukee v. Cement Div. Nat'l Gypsum Co.*, —— U.S. ——, ——, 115 S.Ct. 2091, 2096, 132 L.Ed.2d 148 (1995) (stating that the allowance of prejudgment interest "rests very much in the discretion of the tribunal which has to pass upon the subject, whether it be a court or a jury" (quoting *The Scotland*, 118 U.S. 507, 518-19, 6 S.Ct. 1174, 1175-76, 30 L.Ed. 153 (1886))); *Dynamics Corp. v. United States*, 766 F.2d 518, 520, 226 USPQ 622, 623 (Fed.Cir.1985) (holding that prejudgment interest may include compound interest). The government has failed to establish that the court abused its discretion in fixing the delay damages.

B. The government argues that *Hughes VII* should not be the law of the case after this court's *in banc* decision in *Pennwalt*. Thus, it asserts that "store and execute" (S/E) spacecraft do not infringe the Williams patent and should not be included in the compensation base.

In *Hughes VII*, this court noted two differences between the S/E spacecraft and the claimed invention of the Williams patent that precluded a finding of literal infringement: (1) certain of the S/E spacecraft do not contain the means for providing an indication of instantaneous spin angle (ISA) to ground control required by paragraph (e) of claim 1; and (2) none of the S/E spacecraft contain the means for receiving control signals for immediate execution required by paragraphs (f) and (g) of Claim 1.[3] 717 F.2d at 1361,

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[3] These paragraphs of claim 1 read as follows:

> e. means disposed on said body for providing an indication to a location external to said body of the instantaneous spin angle position of said body about

219 USPQ at 480. This court held, however, that the S/E spacecraft infringed the Williams claims under the doctrine of equivalents. The *Hughes VII* opinion noted that the trial court's doctrine of equivalents analysis failed to apply the doctrine properly to the claimed invention and erred in requiring "obvious and exact equivalents" for claim limitations. *Id.* at 1364, 219 USPQ at 482. Based on the specification and engineering evidence, the court concluded that "retention of the ISA position in an on-board computer, while transmitting sufficient information to enable the ground crew to use that computer-retained information to control the satellite, is the modern-day equivalent of providing an indication of ISA to ground" as required by paragraph (e) of claim 1. *Id.* at 1365, 219 USPQ at 483. It also determined that the external synchronization of the command signal with the ISA position as specified in paragraphs (f) and (g) is equivalent to the internal synchronization accomplished onboard the S/E spacecraft by using modern memory circuits. *Id.* at 1366, 219

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said axis and the orientation of said axis with reference to a fixed external coordinate system;

f. and means disposed on said body for receiving from said location control signals synchronized with said indication;

g. said valve being coupled to said last-named means and responsive to said control signals for applying fluid to said fluid expulsion means in synchronism therewith for precessing said body to orient said axis in a predetermined desired relationship with said fixed external coordinate system.

See Hughes VII, 717 F.2d at 1355, 219 USPQ at 475-76, for the entire claim 1.

USPQ at 484. The court said that use of ISA information onboard as a reference point for firing the jet, instead of using the ISA information on the ground as a reference point, was merely a relocation in the function and did not change the function performed, the manner of operation, or the result obtained. *Id.* at 1366, 219 USPQ at 484.

Four years after *Hughes VII*, this court sitting in banc stated in Pennwalt that it was well settled under the doctrine of equivalents "that each element of a claim is material and essential, and that in order for a court to find infringement, the plaintiff must show the presence of every element or its substantial equivalent." 833 F.2d at 935, 4 USPQ2d at 1739- 40 (quoting *Perkin-Elmer Corp. v. Westinghouse Elec. Corp.*, 822 F.2d 1528, 1523-33, 3 USPQ2d 1321, 1324-25 (Fed.Cir.1987)). The dissenting opinion in Pennwalt asserted that the majority was requiring the "obvious and exact equivalents" requirement that was rejected in *Hughes VII*. *Id.* at 941-42, 4 USPQ2d at 1744-45 (Bennett, S.J., dissenting).

The government now argues that *Hughes VII* is inconsistent with *Pennwalt* primarily on the basis of the views expressed in the dissenting opinion. We, of course, have the power to revisit the decision of the *Hughes VII* court. The Supreme Court has instructed, however, that this power of courts to revisit their own prior decisions should be sparingly exercised by stating that "as a rule courts should be loathe to do so in the absence of extraordinary circumstances such as where the initial decision was 'clearly erroneous and would work a manifest injustice.'" *Christianson v. Colt Indus. Operating Corp.*, 486 U.S. 800, 817, 108 S.Ct. 2166, 2178, 100 L.Ed.2d 811, 7 USPQ2d 1109, 1117 (1988) (quoting

Arizona v. California, 460 U.S. 605, 618 n. 8, 103 S.Ct. 1382, 1391 n.8, 75 L.Ed.2d 318 (1983)). The government has failed to show that any such circumstances exist.

In *Hughes VII* the court was faced with applying the doctrine of equivalents to a claim written in means plus function language, and thus had to apply the doctrine of equivalents to a claim which under 35 U.S.C. § 112, ¶ 6, included the structure of the specification and equivalents. The court concluded in this instance that the trial court had required "obvious and exact equivalents" which made the doctrine of equivalents analysis the same as for literal infringement, and that the court had, therefore, erred as a matter of law in applying that doctrine. 717 F.2d at 1364, 219 USPQ at 482.

In *Hughes VII*, as discussed above, the court noted the similarities and the differences between the claimed invention and the S/E spacecraft and the fact that the teachings of Williams were used to develop the S/E spacecraft. *Id.* at 1365-66, 219 USPQ at 482-83. It then considered each claim limitation not literally found in the S/E spacecraft and looked at whether the elements of the S/E spacecraft performed the same function in substantially the same way to obtain the same result. *Id.* at 1365-66, 219 USPQ at 483-84. Because there was an equivalent for each claim limitation not literally met, *Id.* at 1365- 66, 219 USPQ at 483-84, the court concluded that the differences between the claimed invention and the S/E spacecraft were too insubstantial to avoid liability under the doctrine of equivalents. *See id.* at 1365, 219 USPQ at 483 ("Advanced computers and digital communications techniques developed since Williams permit doing on-board a part of what Williams taught

as done on the ground. . . . [A]n embellishment made possible by post-Williams technology, does not allow the accused spacecraft to escape the 'web of infringement.'" (quoting *Bendix Corp. v. United States*, 220 Ct.Cl. 507, 600 F.2d 1364, 1382, 204 USPQ 617, 631 (1979))).

This analysis in the court's prior decision is therefore entirely consistent with Pennwalt, as well as this court's more recent in banc decision in *Hilton Davis v. Warner-Jenkinson Co.*, 62 F.3d 1512, 35 USPQ2d 1641 (Fed.Cir.1995), *cert. granted*, —— U.S. ——, 116 S.Ct. 1014, 134 L.Ed.2d 95 (1996). There is no indication in the majority opinion in *Pennwalt* that *Hughes VII* was being overruled or that it was inconsistent with *Pennwalt*. Moreover, one member of the majority expressly countered the assertion of inconsistency put forth by the dissent by stating that *Hughes VII* merely distinguished equivalency in a doctrine of equivalents analysis from equivalency of structure of disclosed means in a § 112, ¶ 6 analysis. *Id.* at 949, 953, 4 USPQ2d at 1751, 1755 (Nies, J., additional views).

In *Hilton Davis*, we stated that the "application of the doctrine of equivalents rests on the substantiality of the differences between the claimed and accused products or processes, assessed according to an objective standard." 62 F.3d at 1518, 35 USPQ2d at 1645. We noted that the function/way/result test is properly used in many cases to measure the substantiality of the differences. *Id.* at 1518, 1522, 35 USPQ2d at 1645, 1648. Moreover, we stated that "the trial judge does not have discretion to choose whether to apply the doctrine of equivalents when the record shows no literal infringement" and may consider such evidence as copying. *Id.* at 1519, 35 USPQ2d at 1646. As de-

scribed above, the *Hughes VII* court applied these very principles.

The dissent apparently would decide *Hughes VII* differently if the case were before this panel, arguing that the approach taken by the *Hughes VII* dissent is the approach required under current law. This is not, however, a sufficient justification to refuse to follow law of the case. There is little doubt that this was a close case and reasonable minds could differ on the proper outcome of *Hughes VII*. Indeed, one member of the Hughes VII court dissented. That this was a close case, however, counsels in favor of abiding by the law of the case. *Christianson*, 486 U.S. at 819, 108 S.Ct. at 2179, 100 L.Ed.2d 811, 7 USPQ2d at 1117 ("'The doctrine of law of the case is . . . a heavy deterrent to vacillation on arguable issues.'" (quoting 1B James W. Moore, et al., Moore's Federal Practice ¶ 0.404[1] (1984))). Simply because a different panel might reach a different conclusion, does not mean that the earlier decision is "clearly erroneous." *See id.*

The dissent makes the further point that we should not consider the length of time this litigation has been pending and urges the court to stay the issuance of this decision until the Supreme Court decides *Hilton Davis*. Because no showing was made to justify staying the decision in this case, we should not ignore the fact that it has been ongoing for over twenty-three years. The "promptness of decision . . . in all judicial actions is one of the elements of justice." *Forsyth v. City of Hammond*, 166 U.S. 506, 513, 17 S.Ct. 665, 668, 41 L.Ed. 1095 (1897). The litigants in this action deserve finality. Over such a long period of time, the composition of the panels of this court and the judge assigned to the case at the

trial level has necessarily changed. As a matter of course, different judges looking at the same case may not view it in the same way. But under the law of the case, we must give respect and force to legal decisions rendered by earlier panels, absent a clear showing of error or injustice. Any other result would unduly prolong this already drawn-out litigation.

CONCLUSION

The judgment of the Court of Federal Claims is affirmed for the reasons above set forth.

AFFIRMED.

BRYSON, Circuit Judge, concurring.

There is substantial force to Judge Nies's analysis of the doctrine of equivalents issue in this case. But while I agree with much of what she says, I cannot join the disposition that she proposes.

This court's law on the doctrine of equivalents has certainly evolved over time, and the first *Hughes* appeal comes from well back in this court's history. It may well be that if we were writing on a clean slate we would view the doctrine of equivalents issue in this case differently now than the court did at that time. Because the first *Hughes* appeal decided the equivalents issue, however, we are not free to address the issue *de novo*, as if the first appeal had not occurred or as if it were merely an interesting historical byway in the seemingly endless course of this litigation. The law-of-the-case doctrine counsels strongly against one panel's overturning an earlier panel's resolution of the same issue in the same case. Based on that doctrine, I join the opinion of the court in this case.

If the law-of-the-case doctrine is to have any substance, it must sometimes require a judge to uphold a ruling on a question that the judge would decide the other way if it were presented for the first time. In order to serve the interests of judicial economy, finality, and avoidance of "panel-shopping," the doctrine strongly discourages reconsideration of issues that a previous panel has addressed, fully considered, and decided. *See Roberts v. Cooper*, 61 U.S. 467, 481, 20 How. 467, 15 L.Ed. 969 (1857) ("there would be no end to a suit if every obstinate litigant could, by repeated appeals, compel a court to listen to criticisms on their opinions, or speculate of chances from changes in its members"); *Central Soya Co. v. Geo. A. Hormel & Co.*, 723 F.2d 1573, 1580, 220 USPQ 490, 495 (Fed.Cir.1983). Moreover, in patent cases, where Congress has made special provision for interlocutory appeals, *see* 28 U.S.C. § 1292(c)(2), adherence to the law-of-the-case doctrine is especially important, as there are more opportunities for a party dissatisfied with a ruling from one panel to seek a different result from a second.

As a general matter, courts apply the law-of-the-case doctrine except when the case for departure is exceptionally clear, either because the controlling law has changed or the earlier decision is clearly erroneous and would lead to manifest injustice. *See Mendenhall v. Barber-Greene Co.*, 26 F.3d 1573, 1582, 31 USPQ2d 1001, 1007 (Fed.Cir.), *cert. denied*, —— U.S. ——, 115 S.Ct. 582, 130 L.Ed.2d 496 (1994); *Perkin-Elmer Corp. v. Computervision Corp.*, 732 F.2d 888, 900, 221 USPQ 669, 679 (Fed.Cir.) (departures from the law of the case doctrine occur "very infrequently"; the clearly erroneous/manifest injustice exception is "stringent" and requires a "strong

showing of clear error"), *cert. denied*, 469 U.S. 857, 105 S.Ct. 187, 83 L.Ed.2d 120 (1984); *see also Smith Intern., Inc. v. Hughes Tool Co.*, 759 F.2d 1572, 1576-80, 225 USPQ 889, 891-94 (Fed.Cir.), *cert. denied*, 474 U.S. 827, 106 S.Ct. 87, 88 L.Ed.2d 71 (1985). Whatever view I might take on the merits if the doctrine of equivalents issue in this case were before us for the first time, I do not think the prior disposition is so clearly erroneous or has so plainly been overtaken by subsequent developments that the law-of-the-case doctrine can be disregarded.

Judge Nies makes the separate point that, in light of the pendency of *Hilton Davis Chemical Co. v. Warner-Jenkinson Co., Inc.* in the Supreme Court, the wisest course for us would be to suspend resolution of this appeal until the Supreme Court decides that case. To bring this long-pending litigation to a close on the eve of what might be a dispositive resolution of the doctrine of equivalents issue, Judge Nies argues, would be injudicious.

If I felt that the panel's decision were the last stop on the voyage of this case, I might well agree with Judge Nies. But it is not the last stop. Besides seeking rehearing in this court, the government can petition for certiorari from the Supreme Court, with a request that the Court hold the case pending the disposition of *Warner-Jenkinson*. Thus, our decision today is not likely to deprive the government of the chance for a favorable judgment by stealing a march on the Supreme Court.

But why should we issue this decision if the result will simply be to put the government to the task of going through additional procedural steps to keep the judgment from becoming final while the government is waiting for the Supreme Court to decide *Warner-*

Jenkinson? There are several reasons. First, we have a number of issues to resolve in addition to the doctrine of equivalents question. The panel is unanimous as to all but one of those issues. The resolution of the other issues may be useful in limiting the points on which the parties are in disagreement (it may be too much to hope that resolving some of the issues will provide a meaningful impetus to settlement in this case, but more information is usually better than less). In addition, we cannot realistically suspend the proceedings in every case that could potentially be affected by the *Warner-Jenkinson* decision, which may be as much as a year away. One of the unfortunate features of the doctrine of equivalents as it has developed over time is that it has come to play a crucial role in a large percentage of patent infringement actions. If we hold this case pending the Supreme Court's decision in *Warner-Jenkinson*, how could we justify not suspending the appeal in every case raising a plausible doctrine of equivalents claim that comes before this court over the next year? Finally, the government has not asked us to suspend this appeal, even though the Supreme Court granted certiorari in *Warner-Jenkinson* several months ago. I assume that if the government felt strongly that its rights were at risk if this court should choose to apply law-of-the-case principles without awaiting a Supreme Court decision, we would have heard from government counsel by now. Absent a request for suspension, I agree that we should treat this case as we treat all others and decide it as soon as a disposition is ready, leaving the parties to protect their interests, if they choose, through the avenues of further review.

NIES, Senior Circuit Judge, dissenting.

I.

This appeal raises a novel question respecting the application of principles of "law of the case." In 1983, this court reversed a judgment of the United States Claims Court, *Hughes Aircraft Co. v. United States*, 215 USPQ 787 (Cl.Ct.1982) (*Hughes VI*) that certain store and execute (S/E) satellites did not infringe the claims of Hughes' U.S. Patent No. 3,758,051 (the '051 patent) under the doctrine of equivalents and remanded the case for a determination of damages. *Hughes Aircraft Co. v. United States*, 717 F.2d 1351, 219 USPQ 473 (Fed.Cir.1983) (*Hughes VII*). Upon remand, Hughes asserted that an additional 94 spacecraft, differing in various ways from those that had been litigated, also used the '051 invention. Subsequent lengthy trial court proceedings resolved the issues of liability respecting these devices. The judgment now before us fixes the amount of compensation due under 28 U.S.C. § 1498.

II.

Hughes VII was one of the first cases of this court to present the issue of infringement under the doctrine of equivalents and resulted in a split decision. Some understanding of the technology and of the different views of the panel is helpful at this point. The '051 patent is directed to a system for control of a spin-stabilized communications satellite. The patent explains that communications over long distances are possible if the satellite is accurately placed and maintained in a "geosynchronous" orbit. In such an orbit, the position of the satellite and its velocity are such that the satellite appears to hover over one point on

the Earth's surface. Accurate placement and maintenance of the geosynchronous orbit maximizes communications potential.

The importance of satellite placement gives rise to the need to correct for satellite drift. Williams teaches countering satellite drift in real-time by intermittently pulsing attitude control jet valves, which are located on the periphery of the satellite, thereby tilting or "precessing" the satellite. A radio transmitter on the satellite sends instantaneous spin angle (ISA) position and orientation information to a ground crew on Earth. Once the satellite's existing and desired orientations are determined, the ground crew transmits control signals to the satellite which are synchronized with the spin position and orientation. In response, the control valves are immediately pulsed, precessing the satellite into position.

Claim 1 which is representative of the claims in suit requires (a) a body adopted to spin about an axis; (b) a fluid supply; (c) a valve connected to the fluid supply; (d) fluid expulsion means oriented to expel fluid, and the following additional elements:

> (e) means disposed on said body for providing an indication to a location external to said body of the instantaneous spin angle position of said body about said axis and the orientation of said axis with reference to a fixed external coordinate system;
>
> (f) and means disposed on said body for receiving from said location control signals synchronized with said indication;
>
> (g) said valve being coupled to said last-named means and responsive to said control signals for

> applying fluid to said fluid expulsion means in synchronism therewith for precessing said body to orient said axis in a predetermined desired relationship with said fixed external coordinate system.

The government spacecraft in issue do not send information to the ground crew and are not precessed upon a signal sent by the ground crew but are controlled by a stored program in an on-board computer, *i.e.*, a store and execute system (S/E).

The majority, nevertheless, concluded that S/E spacecraft infringe because:

> The failure to apply the doctrine of equivalents to the claimed invention as a whole, and the accompanying demand for "obvious and exact" equivalents of two elements the presence of which would have effectively produced literal infringement, was error.
>
> . . . .
>
> [T]he S/E spacecraft, with the ISA position indication retained on-board, are equivalents of Williams' claimed satellite, with the ISA position indication sent to ground, performance of the function involving the ISA position being substantially the same in each. We agree.
>
> . . . .
>
> The S/E spacecraft uses sun pulses retained on-board as reference points to fire the jet. Williams uses sun pulses sent to ground as reference points to fire the jet. The difference between operation by retention and operation by sending is achieved by relocating the function,

making no change in the function performed, or in the basic manner of operation, or in the result obtained.

. . . .

The S/E spacecraft and the claimed Williams satellite reflect the precise circumstance envisaged in *Graver*, *supra*, for they perform the same function (receipt of and response to command signals from an external location to accomplish precession), in substantially the same way (jet firings synchronized, albeit later and internally, with ISA position) to obtain substantially the same result (controlled precession of spin axis in a predetermined direction to orient a hovering satellite).[4]

717 F.2d at 1364-66, 219 USPQ at 482-484.

One panel member, Judge Davis, agreed with the trial court that one or more elements required by the claims was not present in the accused S/E satellites, either exactly or by an equivalent thereof. More particularly, he would have affirmed the trial court's finding, *inter alia*, that the accused devices had no equivalent for the required "means . . . providing an

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[4] I note that the damage award is based on hovering and non-hovering government spacecraft. It is not disputed that most of the accused satellites are operated in non-geosynchronous orbits, i.e., the satellites and the Earth move at different angular velocities, and therefore, unlike Williams' satellite, do not have to account for the propagation delay in transmitting the control signals between the satellite and Earth. The majority's finding of infringement did not, however, distinguish between hovering and non-hovering satellites.

indication" of the ISA "to an external location."[2] The claims expressly call for an attitude control system, a structure, on the spinning body which sends information on the ISA to a ground controller, who determines when a jet should be fired based in part on the ISA information. Judge Davis concluded:

> To find, as the majority does, in this self-contained on-board computer an equivalent of the specific requirement for providing an indication of ISA to the ground (so that the ground can take account of ISA) is simply to obliterate and disregard this element of the claims. These

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[2] Judge Davis also concluded respecting other elements:

> 3. The same is true of the elements specifying the method for controlling the precession jet. In this regard, Williams, again as Judge Colaianni points out, limits its claims so as to require a ground controller, not only to determine the ISA, but also to use the ISA to pulse the precession jet during the desired portion of the spin cycle. As to the latter, the claims in suit also require means for pulsing the precession jet within a fixed time period after the receipt of the control signal. This does not occur in any of the accused structures, nor does the ground location use ISA to determine the execute command.
>
> . . . . Moreover, in Williams there must be a fixed time period between the receipt by the spacecraft of a control signal and the activation of the precession jet. In the S/E satellites, in contrast, neither the ground nor the execute signal operates to activate the precession jet within a fixed time period (instead, that period varies). The sum of it is that the S/E structures perform a "different function" in a "different way" from those claimed by Williams—and are therefore not within the *Graver* principle.

717 F.2d at 1367-68, 219 USPQ at 485-86.

accused structures may possibly obtain "the same result" as Williams but they do not perform "the same function" in "the same way" either literally or substantially. Whether or not this on-board device for calculation would be unobvious—and there is no finding and (to my mind) no showing that it would have been obvious—its substitution was not a proper equivalent for infringement of this non-pioneer patent because the wholly on-board computer device operated in a different way to perform the different function of a significant calculation unrelated to ground personnel.[3] Unlike the Court of Claims decisions cited in the court's opinion this is not the case of a "sophisticated" technique of performing the same function in the same way. It is a "sophisticated" method of performing a different function in a different way. Even if the standard of "obvious and exact equivalents" (*Eastern Rotorcraft Corp. v. United States*, 397 F.2d 978, 982, 184 Ct.Cl. 709, 158 USPQ 294 (1968)) is considered as too narrow, the accused devices here are definitely outside the equivalence principle of *Graver Tank & Mfg. Co. v. Linde Air Products Co.*, 339 U.S. 605, 608, 70 S.Ct. 854, 856, 94 L.Ed. 1097 (1950).

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[3] The majority quotes Hughes' expert as testifying that it would have been obvious to place the calculating device on the spacecraft but the Government's witnesses testified that this device was not an equivalent.

717 F.2d at 1367, 219 USPQ at 485.

The government argues in its brief and at the hearing that the *Hughes VI* finding of *noninfringement* by S/E satellites would be affirmed under the precedent of *Pennwalt Corp. v. Durand-Wayland, Inc.*, 833 F.2d 931, 4 USPQ2d 1737 (Fed.Cir.1987) (*in banc*), *cert. denied*, 485 U.S. 961, 108 S.Ct. 1226, 99 L.Ed.2d 426, 485 U.S. 1009, 108 S.Ct. 1474, 99 L.Ed.2d 703 (1988), and its progeny; and that it should not be held liable for infringement of the ' 051 patent for acts which would not constitute infringement by anyone else. Further it urges that this court must apply the law of *Hilton Davis Chemical Co. v. Warner-Jenkinson Co.*, 62 F.3d 1512 (Fed.Cir.1995) (*in banc*), *cert. granted*, —— U.S. ——, 116 S.Ct. 1014, 134 L.Ed.2d 95 (1996), an *in banc* case on the doctrine of equivalents then pending, whatever the holding might be. Hughes counters that *Hughes VII* is not in conflict with *Pennwalt* and that, in any event, this court should not revisit liability issues after these many years even if the law in the *Hughes VII* decision is wrong. In addition, Hughes argues that the government waived its right to reargue that its S/E satellites do not use the '051 invention because the government did not argue below that the law had changed. Respecting *Hilton Davis*, Hughes argues that it would be manifestly unjust to apply retroactively any new test that might be adopted therein.

III.

Unlike *res judicata*, the law of the case does not involve preclusion after final judgment, but rather it regulates judicial affairs before final judgment. 18 CHARLES A. WRIGHT, ET AL., FEDERAL PRACTICE AND PROCEDURE § 4478 (1981). A court will not generally revisit an issue once decided during the course of

litigation. "Although courts are often eager to avoid reconsideration of questions once decided in the same proceeding, it is clear that all federal courts retain power to reconsider if they wish." *Id.* As Justice Holmes stated, the law of the case doctrine "merely expresses the practice of courts generally to refuse to reopen what has been decided, not a limit to their power." *Messenger v. Anderson*, 225 U.S. 436, 444, 32 S.Ct. 739, 740, 56 L.Ed. 1152 (1912). The Supreme Court has also explained that "there is a difference between [law of the case] and res judicata; one directs discretion, the other supersedes it and compels judgment." *Southern Ry. Co. v. Clift*, 260 U.S. 316, 319, 43 S.Ct. 126, 127, 67 L.Ed. 283 (1922). *See also Arizona v. California*, 460 U.S. 605, 618, 103 S.Ct. 1382, 1391, 75 L.Ed.2d 318 (1983). Thus, Hughes is correct that a court has some discretion under "law of the case" principles. However, the federal courts of appeals have uniformly recognized that an intervening change in applicable law is a strong basis for reconsideration of a decided issue in a pending case. *Dean v. Trans World Airlines, Inc.*, 924 F.2d 805, 810 (9th Cir.1991) (Supreme Court decision changed applicable law); *Miles v. Kohli & Kaliher Associates, Ltd.*, 917 F.2d 235, 242 (6th Cir.1990) (state Supreme Court decision changed applicable law in diversity case); *Doe v. Anrig*, 728 F.2d 30, 31 (1st Cir.1984) (decision by the same court of appeals changed applicable law); *Wooster v. Handy*, 21 F. 51, 53-54 (C.C.S.D.N.Y.1884) (decree of patent validity reconsidered after Supreme Court decisions relating to the validity of reissued patents).

A.

As an initial matter, Hughes' argument is clearly untenable that the government has "waived" its right to argue for application of the current law at this stage of the proceedings. The government conceded only that, under our prior Hughes decision, certain additional S/E satellites could not be distinguished from the ones already found to be infringing. Nor could the government appropriately argue to the trial court that it did not have to follow the explicit mandate of this court during the course of the later damages phase because of a change in the law. The trial court must follow the appellate court mandate until the appellate court itself changes it. In *re Roberts*, 846 F.2d 1360, 1363, 6 USPQ2d 1772, 1774 (Fed.Cir.1988) ("Unlike the authority to reconsider its own rulings, a district court is without choice in obeying the mandate of the appellate court."). However, at all times, the government expressly preserved the S/E infringement issue for appeal, and Hughes does not challenge the right of the government to petition the Supreme Court for review of all infringement issues. Finality of decision has not been achieved for purposes of further appeal until the majority decision today. Hughes simply argues for our adherence to the law of the case.

There can be no question that the Supreme Court would apply the current law to a pending case. *See, e.g., United States Surgical Corp. v. Ethicon*, — U.S. ——, 116 S.Ct. 1562, 134 L.Ed.2d 662 (1996) (remanding case to apply ruling in *Markman v. Westview Instruments, Inc.*, 517 U.S. ——, 116 S.Ct. 1384, 134 L.Ed.2d 577 (1996) to case decided prior thereto). Therefore, it makes no sense to hold that this court should not

apply current precedent to correct its decision in a pending case. If the law applied in *Hughes VII* is no longer the law in this circuit, this court has an obligation, under the principles of law of the case, to revisit that issue if failure to do so would work a manifest injustice.

B.

Nor should the passage of time work against the government's position. While *Hughes VII* was decided 14 years ago, the delay in the presentation of the issue of "law of the case" has not been due to the government's procrastination. Hughes's assertion that additional spacecraft infringed required extensive trials on disparate issues, *e.g.*, whether some were held covered by a release to the manufacturer which they were. The government has not merely been "hoping that the passage of time or change in the composition of the court will provide a more favorable result the second time," as in a case cited by Hughes, *United States v. Turtle Mountain Band of Chippewa Indians*, 222 Ct.Cl. 1, 612 F.2d 517, 520 (1979). In that case the government sought reconsideration of an issue fully argued and rejected before. Hughes ellipses from the quotation, "No litigant deserves an opportunity to go over the same ground twice, hoping . . . [for a change in the court's view]." Here, the government argues that the law has been changed in other cases since the first decision.

IV.

It would be surprising, indeed, if no development of the law of infringement had occurred over the 14 years since *Hughes VII*, and one would have to bury one's head in the sand to hold it has not. Not only has the test for infringement been restated and refined as

in the "All Elements rule" stated in Pennwalt, the rejection of functional equivalency as the test for infringement in *Atlanta Motoring Accessories, Inc. v. Saratoga Technologies, Inc.*, 33 F.3d 1362, 1366 (Fed.Cir.1994), and the "insubstantial change rule" set forth in *Hilton Davis*, discussed *infra*, but also the correct standards of review of a judgment of infringement were also later articulated for the first time.

Hughes argues that only an outright reversal of the substantive law applied in reaching a decision warrants departure from "law of the case." I find no controlling authority so holding. If the law has evolved to such an extent that the result in the case would be different, law of the case principles do not require blind adherence to a wrong result. Conversely, if the result would be the same under current precedent, any error in a prior opinion would be harmless. This brings us to the question of what disposition should be made in this case of the S/E infringement issues.

The dissent in *Hughes VII* made the type of analysis which must be made under current case law. The actual structure of the specified components of the invention and of the accused devices was considered by the dissenter, not merely the overall equivalency or even the "equivalent" functions of the substituents, to which the majority limited its analysis. *Atlanta Motoring*, 33 F.3d at 1365-66 (merely functional equivalents not enough for infringement under doctrine); *Johnston v. IVAC Corp.*, 885 F.2d 1574, 1580, 12 USPQ2d 1382, 1387 (Fed.Cir.1989) (structual equivalency of "means" element required under § 112 ¶ 6). Further, the majority essentially performed a de novo review of the facts

and law. The majority held no factual finding of the trial court clearly erroneous respecting the non-equivalency of the accused components, *Insta-Foam Prods., Inc. v. Universal Foam Sys., Inc.*, 906 F.2d 698, 702 (Fed.Cir.1990) (determination of equivalent elements under the doctrine is a question of fact reviewed under clearly erroneous standard); it also did not remand for new factual findings after holding that the trial court erred "as a matter of law," *Panduit Corp. v. Dennison Mfg. Co.*, 810 F.2d 1561, 1565, 1 USPQ2d 1593, 1595 (Fed.Cir.1987) (in view of legal error, appellate court should remand for trial court to make the missing findings); and it either ruled on equivalency as a matter of law contrary to *Hilton Davis*, 62 F.3d at 1522, 35 USPQ 2d at 1648 (finding of infringement under the doctrine of equivalents reviewed as a question of fact; not legal or equitable issue) or it substituted findings of its own that the different control system of the accused satellites was equivalent contrary to *Atlantic Thermoplastics Co. v. Faytex Corp.*, 5 F.3d 1477 (Fed.Cir.1993) ("fact-finding by the appellate court is simply not permitted"). Either way, the majority's free wheeling "review" was not in accord with the appellate standards now followed by this court.

V.

This court handed down a plethora of opinions in *Hilton Davis*. The majority says it merely "restated" the law by returning the doctrine to the original moorings of *Graver Tank* that only insubstantial changes from the claim fall within the doctrine. Three dissenting opinions and one concurrence were filed setting out widely divergent views of the law.

The Supreme Court has recently taken *Hilton Davis* for review, its first case on the doctrine of equivalents under the Patent Act of 1952. The petitioner therein urges that literal infringement (which includes equivalents only under 35 U.S.C. § 112 ¶ 6) should be the sole basis for liability and that the judicially created doctrine of equivalents should be abandoned because it is inconsistent with the current statute. Petitioner argues further that the test for nonliteral infringement set forth in *Hilton Davis*, directed to the "insubstantiality of the differences" from the claimed invention, deprives the public of notice of patent boundaries, offers protection not approved by the PTO, and overrides the statutory reissue provisions. *Brief of Petitioner Warner-Jenkinson*, pp. 13-27. Petitioner urges the Court, at most, to recognize nonliteral infringement only where known equivalents are disclosed in the patent application, the situation in *Graver Tank*. *Brief of Petitioner Warner-Jenkinson*, at 38-41.

The Supreme Court's rulings on these issues can be expected to have a major impact on the law of infringement. I conclude that the majority opinion in *Hughes VII* conflicts not merely with the dissents in *Hilton Davis*, but with the majority as well. I would, therefore, suspend this appeal pending the Supreme Court's decision in *Hilton Davis*.[3] A few months of

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[3] Contrary to statements by my colleagues, I do not advocate suspending other pending doctrine of equivalent cases. Such cases should be decided in accordance with principles set forth in this court's majority decision in *Hilton Davis*. *Hughes VII* does not meet that test and raises the important issue of whether a substituent in the combination must have been a known equivalent. Without analysis, *Hughes VII* holds that later developed technology can be an infringing equivalent

delay is insignificant in a suit of this magnitude which has been pending since 1973. In my view, it would be a manifest injustice to the people of the United States to end this case and approve the payment of millions of dollars in compensation to Hughes when the law imposing liability is in a state of such uncertainty.

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contrary to Supreme Court precedent, *see e.g., Halliburton Oil Well Cementing Co. v. Walker*, 329 U.S. 1, 13, 67 S.Ct. 6, 12, 91 L.Ed. 3 (1946).

APPENDIX B

UNITED STATES COURT OF FEDERAL CLAIMS

No. 426-73

HUGHES AIRCRAFT COMPANY, PLAINTIFF

v.

UNITED STATES OF AMERICA, DEFENDANT

[Filed: Aug. 16, 1993]

OPINION ON LIABILITY

TURNER, Judge.

Hughes Aircraft Company owns U.S. Patent No. 3,758,051, entitled "Velocity Control and Orientation of a Spin-Stabilized Body," which describes an apparatus for controlling the attitude of a spin-stabilized spacecraft.[1] Hughes brought this action pursuant to 28 U.S.C. § 1498, seeking just compensation for the unauthorized use or manufacture by or for the government of spacecraft containing an embodiment of the patented apparatus. Hughes seeks compensation in excess of four billion dollars. This opinion

[1] The patent, which was first used in the early 1960's in the communication satellites SYNCOM II and III, was issued to Hughes on September 11, 1973 as assignee of inventor and former Hughes employee, Donald D. Williams. The Williams patent expired on September 11, 1990.

addresses all previously unresolved liability issues; an opinion addressing damages will follow.

I

A

Hughes filed its complaint on November 13, 1973. Since then, the parties have engaged in a lengthy and costly litigation in both trial and appellate courts.

A trial—confined to liability issues pertaining to the 14 spacecraft then accused—was conducted in 1976-77 and resulted in a decision by a trial judge of the Court of Claims that the patent was invalid under 35 U.S.C. § 102(b).[2] *Hughes Aircraft Co. v. United States*, 205 U.S.P.Q. 381 (Ct.Cl. Trial Div.1979). On appeal, a panel of the Court of Claims rejected that conclusion and remanded the case for a determination of the other issues presented. *Hughes Aircraft Co. v. United States*, 226 Ct.Cl. 1, 640 F.2d 1193 (1980). On remand, the trial judge determined that the patent was valid; he also concluded that a group of spacecraft referred to as "real time" spacecraft infringed and that another group of spacecraft referred to as "store and execute" spacecraft did not infringe. *Hughes Aircraft Co. v. United States*, 215 U.S.P.Q. 787 (Ct.Cl. Trial Div.1982). On appeal, the United States Court of Appeals for the Federal Circuit reversed-in-part, concluding that the store and execute spacecraft did infringe, and affirmed in all other respects. *Hughes Aircraft Co. v. United States*, 717 F.2d 1351

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[2] Section 102(b) of title 35, United States Code, bars the issuance of a patent if "the invention was . . . described in a printed publication . . . or in public use . . . in this country, more than one year prior to the date of the application for patent."

(Fed.Cir.1983). The Federal Circuit remanded the matter to this court for a determination of the damages due for the 14 spacecraft adjudged to infringe.[3] *Id.*

Based on this history of the case, the portion of this long-running litigation extending from initial filing through the 1983 decision of the Federal Circuit has been frequently referred to as the "liability" phase, and the portion occurring since the 1983 remand to this court has been referred to as the "accounting" or "damages" phase. However, in addition to the 14 spacecraft adjudged to infringe in the "liability" phase, Hughes has accused 94 spacecraft during this "accounting" phase, for a total of 108 accused spacecraft.[4] (The appendix to this opinion lists each of the 108 spacecraft accused during any stage of this litigation.) Thus, this so-called "accounting" phase has entailed the determination of liability concerning the 94 newly accused spacecraft as well as a determination of damages with respect to any of the 108 spacecraft found to infringe.

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[3] Since the Federal Circuit's decision, Hughes has accused an additional 13 spacecraft from the DSCS II program. Because the Federal Circuit's 1983 decision determined that four spacecraft from that program, DSCS II (1-4), infringed the Williams patent, *see* 717 F.2d at 1366, the government concedes that the 13 newly accused spacecraft from that program also infringed the patent. *See* Appendix to Opinion n. 7.

[4] In addition to the spacecraft found to infringe in the liability phase, Hughes is entitled to recover for any infringing spacecraft used or manufactured by or for the government up to the date of expiration of the patent. *Calhoun v. United States*, 173 Ct.Cl. 893, 354 F.2d 337, 340 (1965). The patent expired on September 11, 1990.

Trial of issues involved in this current "accounting" phase was accomplished in two major parts, one occurring before expiration of the Williams patent on September 11, 1990 and the other occurring thereafter, it having been found more efficient and otherwise appropriate to defer final proceedings concerning 24 specific spacecraft until after patent expiration. The first part involved receipt of evidence in Pasadena, California and Washington, D.C. over a period between February 2 and December 16, 1988, and a series of arguments over a period from February to September 1989. The second part involved receipt of evidence in Pasadena, California between January 15 and 24, 1991 and final argument in May 1991.

During this post-1983 "accounting" phase, the court heard the testimony of 61 witnesses, reviewed the deposition testimony of approximately 95 additional witnesses and received into evidence more than 4500 exhibits; documentary exhibits alone comprise approximately 142 linear feet. The transcript of proceedings over the period from February 1988 through May 1991 includes 20,812 pages.

B

The matter is now matured for final decision on all issues. We assume familiarity with the Federal Circuit's 1983 liability decision, 717 F.2d 1351.[5]

Part II of this opinion briefly describes the Williams patent. Parts III, IV and V address the three

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[5] See our earlier opinion at 15 Cl.Ct. 550, 551 n. 2 (1988), for a list of previously published opinions in this case and other cases involving the Williams patent. The instant opinion is the 14th published opinion directly involving the Williams patent.

remaining groups of liability issues, which can be summarized as follows:

1. Whether the Galileo or Atmosphere Explorer spacecraft infringed the Williams patent under the doctrine of equivalents.

2. Whether the Global Positioning System spacecraft have been manufactured or used with the authorization or consent of the government so that they constitute an infringement of the Williams patent under 28 U.S.C. § 1498.

3. Whether any of the "foreign" spacecraft have been "used" by the government sufficiently to constitute infringement of the Williams patent under 28 U.S.C. § 1498.

II

For our purposes, it is useful to distinguish two types of motion of a spinning object. One is translational motion—the path that the object as a whole travels through space. The second is precession—an alteration of the direction of the axis about which the object spins, also referred to as the "attitude" of the object. To the extent that a force is applied to a body in a direction that does not point precisely toward the center of the body's mass, the force will alter the attitude of the object, i.e., cause the body to precess. Spacecraft that have the ability to alter their translational motion and to control their attitude typically have two sets of thrusters to accomplish the two separate tasks: velocity thrusters to alter the translational motion and attitude thrusters to precess the spacecraft.

The Williams patent discloses an apparatus for controlling the attitude of the spin axis of a

spin-stabilized spacecraft.[6] The patent consists of three independent claims. Because claim one is the broadest of the three, the parties agree that a decision concerning claim one will determine whether the spacecraft in issue infringe claims two and three. Claim one reads as follows:

Apparatus comprising:

a. a body adapted to spin about an axis;

b. fluid supply means associated with said body;

c. a valve connected to said fluid supply means;

d. fluid expulsion means disposed on said body and coupled with said valve and oriented to expel said fluid substantially along a line parallel to said axis and separated therefrom;

e. means disposed on said body for providing an indication to a location external to said body of the instantaneous spin angle position of said body about said axis and the orientation of said axis with reference to a fixed external coordinate system;

f. and means disposed on said body for receiving from said location control signals synchronized with said indication;

g. said valve being coupled to said last-named means and responsive to said control signals

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[6] The advantage of spin stabilization is that the entire spacecraft functions similarly to a gyroscope, i.e., the orientation of the spacecraft remains steady in relation to a fixed external coordinate system. In contrast, another type of attitude control system is a three-axis, or full-body, system. In a full-body system, the spacecraft does not constantly spin and uses small jets pulsing as needed to control the attitude of the spacecraft.

> for applying fluid to said fluid expulsion means in synchronism therewith for precessing said body to orient said axis in a predetermined desired relationship with said fixed external coordinate system.

PX 1.

In a typical application, the Williams patent generally functions as follows.[7] Sun sensors located on one side of a spinning spacecraft transmit electronic pulses to ground control. Those sensors consist of two slits in the shape of a "V". One of the slits is vertical, and the other slit is canted. Each slit is backed by a photocell. Each of the slits sends an electronic pulse to the ground each time it detects the sun. Those pulses enable ground control to determine the spacecraft's spin rate, orientation with respect to the sun and instantaneous spin angle. The spin rate is measured by the time difference between successive pulses from the same photocell. The ground controllers calculate the orientation of the spin axis by measuring the sun angle and the strength of radio signals emitted toward the earth by sensors on the spacecraft. The sun angle is the angle between the spin axis of the spacecraft and a line drawn from the spacecraft to the sun; this is calculated based on the time difference between pulses from the canted and vertical slits. The instantaneous spin angle is the spacecraft's location in its 360 degree revolution at any given instant.

In the Williams invention, the spacecraft is "dumb"; the logic function is performed by ground con-

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[7] *See* 717 F.2d at 1352-54 for additional discussion and a useful diagram of the Williams patent.

trollers.[8] Using the data just described, ground controllers calculate the time delay between the occurrence of a sun pulse and the times at which the jet should be fired to accomplish the desired precession.

Ground control transmits this information to the spacecraft in "real time," i.e., ground control sends a control signal each time it wants the spacecraft's attitude thrusters to pulse, resulting in an instantaneous firing of the thrusters. Ground control continues to send these control signals for each successive spin revolution of the spacecraft until the spacecraft has completed the desired maneuver.

The prior art surrounding this patent and the prosecution history of the patent application have been discussed extensively elsewhere. *See Hughes*, 717 F.2d at 1354-56, 1362-63 (discussing prosecution history); *id.* at 1359-60, 1362 (discussing prior art).

III

In patent litigation, often one of the major issues is whether a patent claim "reads on" the accused device—either literally or by application of the doctrine of equivalents. In this action, that issue has been resolved with respect to all but four of the accused spacecraft. *See* Appendix to Opinion (table describing the infringement determinations for the various spacecraft at issue).

This portion of the opinion addresses whether the attitude control systems of those four spacecraft—Galileo and three Atmosphere Explorer spacecraft

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[8] The Court of Claims previously held that the patent does not require use of any particular type of ground control device. *See Hughes Aircraft Co. v. United States*, 226 Ct.Cl. 1, 8-9, 640 F.2d 1193, 1197-98 (Ct.Cl.1980).

(AE C, D and E)—infringe the Williams patent. Hughes concedes that neither Galileo nor AE literally infringes the Williams patent, but alleges that both spacecraft infringe the patent under the doctrine of equivalents. After describing the attitude control systems of those spacecraft in some detail, we discuss the scope of the doctrine of equivalents and then apply that doctrine to Galileo and the three accused AE spacecraft. We conclude that the attitude control systems of the Galileo and the AE spacecraft do not infringe the Williams patent under the doctrine of equivalents.

A

1. *Galileo*

Galileo is a one-of-a-kind, interplanetary explorer with a mission to explore Jupiter. For most of its mission, Galileo operates as a dual-spin spacecraft with a spinning section and a despun section. A high gain antenna (by which the spacecraft communicates with the earth) and star scanners, among other things, are mounted on the spinning section, and a scan platform and gyroscope assembly are mounted on the despun section. The sections are connected by a spin bearing motor assembly that controls the relative position of the sections. While operating as a dual-spin spacecraft, Galileo uses two modes—a cruise mode, during which the velocity thrusters are firing, and an inertial mode, when they are not. Tr. 7305-07, 15,462.

The attitude control system of Galileo performs three different types of maneuvers—a sun acquisition maneuver, a high gain antenna maneuver and a commanded turn maneuver (Tr. 7783-96). Hughes's

allegation of infringement is limited to the commanded turn maneuver.

Following the lead of the parties, we think the relation between the Williams patent and the commanded turn maneuvers performed by Galileo is adequately illustrated by consideration of a particular commanded turn maneuver referred to as the "turn—burn—re-turn" maneuver. This is the maneuver Galileo uses to change its translational motion, whether the change is a change in the speed of that motion or a change in the direction of that motion. In order to make such a change, Galileo must fire its velocity thrusters in the direction opposite the direction toward which the change in motion will occur. Because Galileo normally travels with its high gain antenna pointing toward earth, it can accomplish this maneuver only if it changes its attitude so that its velocity thrusters are pointing in the correct direction for the desired firing (the "turn" maneuver). Once the velocity thrusters have fired (the "burn"), the spacecraft returns to the original attitude, with its high gain antenna again pointed toward earth (the "re-turn" maneuver). Tr. 7448.

The attitude control system of Galileo performs both the "turn" and "re-turn" procedures described above by controlling the firing of the spacecraft's precession thrusters. The attitude control system of Galileo performs the commanded turn maneuver as follows. Ground control sends Galileo two pieces of information: (1) two coordinates specifying the direction relative to the celestial sphere system[9] that it

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[9] The celestial sphere is an imaginary sphere of infinite extent that contains the earth at its center and the stars and planets. The sphere is used as the fixed external coordinate

wants Galileo to point before firing its velocity thrusters (referred to as EME-50 coordinates)[10] and (2) the desired start-time of the turn maneuver (Tr. 15,483, 15,510). With this information, Galileo's on-board computers perform all the calculations required to turn the spacecraft.

Galileo has V-slit star scanners that ascertain the earth-pointing orientation of the spacecraft with respect to a fixed external coordinate system (the celestial sphere system) by comparing the light received from various stars with star maps stored in its on-board computer memory (Tr. 7688-90). Because the on-board computer knows where the celestial bodies are with respect to the fixed coordinate system, it can calculate the spacecraft's orientation with respect to that system. Then the on-board computer calculates a "turn plane," which is the geometric plane between the spacecraft's present orientation and its desired orientation through which the spin axis will move as the spacecraft precesses. It does this by referring to the coordinates of the present spacecraft orientation as determined from the star maps and the coordinates of the desired orientation as sent from the ground (Tr. 7481-83, 15,473).

Then, an on-board gyroscope is initialized with the present orientation of the spacecraft. Once initial-

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system for celestial navigation. The coordinates sent to Galileo are the right ascension (or azimuth angle) and the declination (or elevation angle) (Tr. 7799).

[10] "EME-50" refers to Earth Mean Equator coordinate system corresponding to the year 1950, which is the system used by Galileo. Because the reference line used in the celestial sphere system (the intersection of the ecliptic plane and the equatorial plane) moves slowly, any reference to that system must include a time designation.

ized, the gyroscope acts as a reference to determine if the spacecraft is correctly turning from its earth-pointing orientation to its desired orientation. Tr. 7765.

The physics of spinning objects dictates that thrusters on a spinning spacecraft must pulse at an angle of 90 degrees with respect to the direction in which the spacecraft will precess (Tr. 7476). Galileo's precession thrusters are fixed so that they fire at a 90 degree angle to the axis of the scan platform. Accordingly, Galileo's scan platform--which, as indicated, is at a 90 degree angle to the precession thrusters—must be aligned with the turn plane (Tr. 7482). The scan platform which is mounted on the despun portion of the spacecraft is connected to the spinning portion of the spacecraft by a spin bearing assembly with an optical encoder containing 360 tick marks, reflecting the 360 degrees in a circle. Galileo's on-board computer rotates the scan platform so that it is aligned with the turn plane by reading those tick marks. Once the scan platform has rotated into the turn plane, the appropriate precession thruster is fired. It is important to note that Galileo does not operate by calculating a time or angle delay from a sun pulse (Tr. 15,637) but instead always fires at the same angle—90 degrees from its target.

Finally, after each thruster pulse, the on-board computer and the gyroscope determine if Galileo has completed the turn by comparing its precessed orientation with the EME-50 coordinates transmitted from ground control. If Galileo has not completed the turn maneuver, the thruster will pulse again on its next revolution. Once the on-board computers determine that the turn is complete, the precession thruster will cease pulsing. This verification process

is referred to as "error nulling." It is critical that Galileo's attitude control system has an error nulling feature because the mission of Galileo requires that its orientation be accurate to at least a tenth of a degree. Tr. 7450, 7458.

It also is relevant that Galileo precesses in what is called a "great circle path," which is the shortest distance between two points on a sphere. By doing so, Galileo is able to minimize fuel use. Galileo is able to precess in this more direct path because it calculates a turn plane that contains the target direction and then always fires its precession jets at a 90 degree angle to the turn plane. Tr. 7637-41.

After turning, the spacecraft's velocity thrusters fire. As explained, the velocity thrusters are not part of the spacecraft's attitude control system but instead control the translational motion of the spacecraft. Once the velocity thrusters have fired, Galileo's on-board attitude control system is now ready to turn Galileo to its initial earth pointing orientation. The attitude control system functions the same way in performing the "re-turn" as it did in performing the "turn." To perform the "re-turn," Galileo's on-board computer recalls the coordinates of Galileo's earth-pointing orientation. The on-board computers calculate a turn plane. The gyroscope is again used as a reference. The scan platform is aligned with the turn plane by referencing the tick marks on the spin bearing motor assembly. The precession thrusters fire until the gyroscope and on-board computers verify completion of the "re-turn" maneuver. Once the spacecraft has completed its "re-turn" maneuver, the high gain antenna is pointing towards the earth and Galileo has totally completed its "turn—burn—re-turn" maneuver. Galileo is then able to receive a

new set of EME-50 coordinates from ground control for its next desired "turn—burn—re-turn" maneuver.

In sum, the only commands ground control sends Galileo are the EME-50 coordinates, which contain the direction Galileo must point before firing its velocity thrusters, and the start time of the "turn" maneuver. The calculations of the turn plane, initialization of the gyroscope, positioning of the scan platform, firing commands for the thrusters, determination of when the spacecraft has reached its desired orientation, and all other commands necessary to perform the "turn" correctly are performed by Galileo's sophisticated on-board computer using a program installed before launch. All similar calculations necessary to perform the "re-turn" maneuver, i.e., to reorient Galileo in its original earth-pointing position, are also performed by the on-board computers, with no additional aid or direction from ground control.

During the entire commanded turn process, communication with ground control is broken because Galileo's high gain antenna is no longer pointing towards the earth (Tr. 7506). Ground control is not able to restore communications with Galileo until after the spacecraft has "re-turned" to its original earth-pointing orientation.

2. *Atmosphere Explorer*

The Atmosphere Explorer ("AE") space program consisted of five spacecraft. The final three of those spacecraft, designated AE C, AE D and AE E, are at issue in this litigation.[11] The attitude control

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[11] The other two spacecraft, AE A and AE B, were not alleged to infringe the Williams patent because they did not con-

systems of those three AE spacecraft were identical for purposes of determining infringement. Accordingly, all three AE spacecraft will be referred to as a single satellite.

The AE spacecraft was a relatively low-cost vehicle that could be launched in a short period of time. The mission of this spacecraft was to measure constituents of the earth's atmosphere at altitudes as low as 130 kilometers. The purpose of those measurements was to further the study of the interaction between ultraviolet rays from the sun and the earth's atmosphere. In order to accomplish its mission, this spacecraft traveled in an elliptical orbit around the earth.

AE was equipped with three methods of attitude control. The system used most often was a magnetic torquing system (practical because of the near-earth orbit of AE). The other methods involved the use of the yaw thrusters in either a despun or spinning mode. Only the spinning yaw mode is accused of infringing the Williams patent. That maneuver was a backup mode to be implemented only if the other modes failed. Also, the spinning yaw maneuver would not have been useful for placing the spacecraft in its permanent orbit; it was designed only to alter the attitude of the spacecraft after it had been placed successfully in its permanent orbit by the other attitude control systems. Although non-use does not avoid infringement (it is uncontested that the accused back-up system was available for use), it is worth noting that the backup yaw precession system accused of infringing the Williams patent was never used

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tain gas powered attitude control systems (DX 2222 (Woodruff deposition)).

to perform a precession maneuver for any of the launched AE spacecraft.

The yaw maneuver was a 180 degree precession of the z-axis (or spin axis) of the spacecraft. The purpose of the maneuver was to allow the earth sensors to keep the earth within their field of view as the spacecraft orbited, while at the same time keeping the side of the spacecraft that carried certain louvers used for temperature control out of direct sunlight. Every few months, AE had to be rotated to prevent those louvers from overheating.

Unlike the commanded turn maneuver that Galileo performs, the yaw maneuver was quite limited. In performing this maneuver, AE turned 180 degrees either clockwise or counter-clockwise. The spacecraft could not reorient itself to any orientation that ground control desired. AE's mission to explore the earth's atmosphere did not require the ability to reorient the spacecraft in multiple directions. The only purpose of the yaw precession system was to flip the spacecraft 180 degrees so that the thermal louvers were kept out of the direct sunlight. Because the mission requirements were much simpler, the attitude control system of the AE spacecraft was likewise much simpler.

Although never used for any of the three launched AE spacecraft (Tr. 8399-8400), ground control could implement the backup yaw precession system by transmitting one set of commands to the AE spacecraft approximately one half-hour in advance of the start-time of the desired maneuver. These commands would consist of a start-time and a stop-time. The spacecraft's on-board computer would have performed all remaining functions necessary to execute the pre-

cession maneuver (Tr. 8392). The following description of such a yaw maneuver assumes implementation.

The yaw maneuver was a precession of the z-axis about the y-axis. The maneuver depended on the knowledge of the precise location of the earth sensors and thrusters with respect to the imaginary axes of the spacecraft. The earth sensors passed the earth once during every revolution of the spacecraft. As the body of the spacecraft passed the earth, the sensors generated a series of pulses; one pulse was generated when the sensors made the sky to earth transition, and another pulse was generated when the sensors made the earth to sky transition. That information allowed AE to determine its spin rate.

AE's attitude control system operated with little aid from ground control. AE synchronized pulsing with the instantaneous spin angle position by using two counters. Those counters were initiated as the earth sensor made the sky to earth transition. The first counted the earth crossing time; the second, driven by a clock ticking 360 degrees per revolution, counted until the spacecraft's y-axis was aligned with the horizon. The first counter then counted down twice as fast as it counted up, reaching zero when the y-axis was directed toward nadir, i.e., when the negative y-axis was pointing at the earth. At that instant a nadir pulse was generated. Accordingly, AE could determine its orientation with respect to the earth. Tr. 8384-86, 8400.

There were four fixed regions or windows during the spacecraft's revolution during which firing could occur; two of the windows were used for yaw maneuvers, and the other two were used for delta-V maneuvers. Each window corresponded to 60 degrees of the spacecraft's rotation (30 degrees of each quarter

revolution were not used). Each window was derived by the use of a counter generating 360 ticks during the spacecraft's revolution. After selecting the proper window (provided by ground control), pulsing was automatic and continuous throughout that window.[12] The thruster firing continued during that portion of the revolution for successive revolutions until the stop-time occurred. Tr. 8400-03.

B

Hughes brought this action under 28 U.S.C. § 1498(a),[13] contending that the government's unlicensed use of the Williams patent constituted a taking. The theoretical basis underlying a patent suit under § 1498 is that the government takes by eminent domain a compulsory, compensable license to use a patented invention whenever the invention is manufactured or used by or for the government. *Motorola, Inc. v. United States*, 729 F.2d 765, 768 (Fed.Cir.1984). Nonetheless, the legal standard

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[12] If the nadir point was referenced at 0 degrees, the windows would begin at 0, 90, 180 and 270 degrees. Ground control could, however, transmit an offset angle to the spacecraft that would shift the start of the window. For example, if ground control sent an offset angle of 20 degrees, the four windows would begin at 20, 110, 200 and 290 degrees.

[13] Section 1498(a) of title 28, United States Code, provides in part:

> Whenever an invention described in and covered by a patent of the United States is used or manufactured by or for the United States without license of the owner thereof or lawful right to use or manufacture the same, the owner's remedy shall be by action against the United States in the United States Court of Federal Claims for the recovery of his reasonable and entire compensation for such use and manufacture.

underlying the term "infringement," as used in patent actions under Title 35, generally is the same as the standard in an action against the government for "unauthorized use." *See Lemelson v. United States*, 752 F.2d 1538, 1548 (Fed.Cir. 1985) ("[P]rinciples of claim construction and reading claims on accused devices and methods are the same for either type of action.").

A patent infringement can be established in one of two ways. Hughes acknowledges the absence of literal infringement for Galileo and AE because elements e, f and g of the Williams patent are not found on the accused devices. *Cf. Hughes Aircraft*, 717 F.2d at 1365 (noting that the "store-and-execute" spacecraft did not literally infringe the Williams patent because they did not send an indication of the instantaneous spin angle to the ground). Hughes predicates its case for infringement on the doctrine of equivalents. Hence, this portion of the opinion addresses the law pertaining to the doctrine of equivalents.

1.

The doctrine of equivalents permits the protection accorded to a patent to exceed the scope of the patent's literal claim language where the accused device is essentially the same as the patented device. *See London v. Carson Pirie Scott & Co.*, 946 F.2d 1534, 1538 (Fed.Cir.1991). The doctrine of equivalents "recognizes a fact of the real business world: words are not misappropriated; claimed inventions are." *Laitram Corp. v. Cambridge Wire Cloth Co.*, 863 F.2d 855, 857 (Fed.Cir.1988), *cert. denied*, 490 U.S. 1068, 109 S.Ct. 2069, 104 L.Ed.2d 634 (1989).

Whether a patent is alleged to be infringed literally or by application of the doctrine of equivalents, analysis of infringement entails two inquiries: "determination of the scope of the claims, as a matter of law" and "the factual finding of whether properly construed claims encompass the accused structure." *Texas Instruments, Inc. v. United States Int'l Trade Comm'n*, 805 F.2d 1558, 1562 (Fed.Cir.1986). The first step—interpreting the scope of the claims—is a question of law. The second step—determining whether a patent claim reads on the accused devices—is a question of fact to be decided under the three-part test set forth in *Graver Tank & Manufacturing Co. v. Linde Air Products Co.*, 339 U.S. 605, 70 S.Ct. 854, 94 L.Ed. 1097 (1950). In that case, the Supreme Court held that "[a] finding of equivalence is a determination of fact" to be made if the accused device "'"performs substantially the same function in substantially the same way to obtain the same result"'" as the patented device. *Graver Tank*, 339 U.S. at 608-09, 70 S.Ct. at 856-57 (quoting *Sanitary Refrigerator Co. v. Winters*, 280 U.S. 30, 42, 50 S.Ct. 9, 13, 74 L.Ed. 147 (1929) (quoting *Machine Co. v. Murphy*, 97 U.S. (7 Otto) 120, 125, 24 L.Ed. 935 (1877))).

For purposes of this case, three judicial doctrines regarding the scope of the doctrine of equivalents have particular importance. First, courts have held that the breadth of equivalents that will be found to infringe a patent depends on the degree to which the patent represents an advance over prior art in the field. A "broad breakthrough invention" or "pioneer invention"—which the Supreme Court has described as one that performs "a function never before performed, a wholly novel device, or one of such novelty and importance as to mark a distinct step in the

(1898); *see Perkin-Elmer Corp. v. Westinghouse Elec. Corp.*, 822 F.2d 1528, 1532 (Fed.Cir.1987). On the other hand, an "improvement [patent] in a crowded art" merits only a "narrow range of equivalents." *Hughes*, 717 F.2d at 1362.

The second relevant doctrine in the law of equivalents is the doctrine of prosecution history estoppel, which "precludes a patent owner from obtaining a claim construction that would resurrect subject matter surrendered during prosecution of his patent application." *Hughes*, 717 F.2d at 1362. "[W]henever the doctrine is evoked, 'a close examination must be made as to, not only what was surrendered, but also the reason for such a surrender.'" *Loctite Corp. v. Ultraseal Ltd.*, 781 F.2d 861, 871 (Fed.Cir.1985) (quoting *Bayer Aktiengesellschaft v. Duphar Int'l Research B.V.*, 738 F.2d 1237, 1243 (Fed.Cir.1984)).

Third, the Federal Circuit has emphasized that a patent owner must show the presence in the accused device of each claim element, or its equivalent. *Pennwalt Corp. v. Durand-Wayland, Inc.*, 833 F.2d 931, 934-35 (Fed.Cir.1987) (*en banc*), *certs. denied*, 485 U.S. 961, 108 S.Ct. 1226, 99 L.Ed.2d 426; 485 U.S. 1009, 108 S.Ct. 1474, 99 L.Ed.2d 703 (1988). Accordingly, even if the overall function, way and result of the patented and accused devices are the same, the absence of an element of the patent claim, or its equivalent, in the accused device means the device cannot infringe. *Id.*

2.

Because the Federal Circuit has discussed extensively the scope of the Williams patent and the range of equivalents to be accorded to the patent, we do not address many of the issues discussed above in the first instance. Instead, there is a significant body of law of the case that is relevant to this decision.

In 1983, the Federal Circuit upheld the validity of the Williams patent and concluded that the patent covered not only the original invention—the "real time" spacecraft—but also a variation developed later—the "store and execute" (S/E) spacecraft. The attitude control system in the S/E spacecraft functioned as follows.[14] Sun sensors sent pulses to an on-board computer that calculated the spin rate and sent that information to the ground. The computer also sent information so that ground control could calculate the orientation of the spacecraft. In most of the S/E spacecraft, ground control did not know or need to know the ISA position. The ground, knowing the spin rate and orientation, then calculated a time delay between the occurrence of the sun pulse and the firing of the thruster. Then, ground control sent spaced signals indicating the position in the spin cycle in which jets should be fired, how many firings should be made and when to begin firing.

The Federal Circuit held that the S/E spacecraft did not literally infringe the Williams patent because of the absence from the S/E spacecraft of a means for providing ground crew an indication of ISA position (element e) and because the precession jets in the S/E

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[14] *See Hughes*, 717 F.2d 1351 (Part II) for additional discussion of the "store and execute" spacecraft.

spacecraft were not fired in "real time." *Hughes*, 717 F.2d at 1361. The court then proceeded to address infringement under the doctrine of equivalents.

The court noted that the prosecution history of the Williams patent application limited the equivalents analysis. *Id.* at 1362. Because Williams chose specific words of limitation to distinguish the patent he sought from a prior invention known as the McLean Space Vehicle (discussed in *Hughes*, 717 F.2d at 1354-55), the court concluded that the Williams patent could not be construed to encompass all structures in which a pulsed jet is used to precess the spin axis of a spin-stabilized body. *Id.* at 1362. In addition, the court concluded that the patented invention was "not of such 'pioneer' status as to entitle the invention to the very broad range of equivalents to which pioneer inventions are normally entitled." *Id.* The court indicated, however, that the patent merited some range of equivalents because it was not merely an "improvement [patent] in a crowded art." *Id.*

Turning to the *Graver* test, the court concluded that the S/E spacecraft had an equivalent to the limitation in clause (e) of the Williams patent (which, as noted above in Part II, generally required a means on the spacecraft for indicating to an external location the spacecraft's ISA and orientation) because "retention of the ISA position in an on-board computer, while transmitting sufficient information to enable the ground crew to use that computer-retained information to control the satellite, is the modern-day equivalent of providing an indication of ISA to ground as taught by Williams." *Id.* at 1365. The court also found an equivalent to clauses (f) and (g) (which, as noted above in Part II, generally required a means on the spacecraft for receiving signals directing how

thrusters should be fired to precess the spacecraft) because the "use of modern memory circuits on-board S/E spacecraft to store commands for later use" is merely "substitution of an embellishment made possible by post-Williams technology." *Id.*

In closing, the court concluded that the S/E spacecraft and the claimed Williams spacecraft

> perform the same function (receipt of and response to command signals from an external location to accomplish precession), in substantially the same way (jet firings synchronized, albeit later and internally, with ISA position) to obtain substantially the same result (controlled precession of spin axis in a predetermined direction to orient a hovering satellite).

Id. at 1366.

Some judges have suggested that there is a conflict between the *Hughes* "invention as a whole" approach and the element-by-element approach set forth in the Federal Circuit's sharply divided *en banc* decision in *Pennwalt Corp. v. Durand-Wayland, Inc.*, 833 F.2d 931 (Fed.Cir.1987).[15] *Pennwalt* involved a patent on

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[15] The *Pennwalt* case produced a seven-judge majority and a four-judge dissent. In addition, Judge Nies, who joined the majority, added a separate writing entitled "additional views," and Judge Newman, who joined the dissent, added a separate writing entitled "commentary." Although the majority opinion did not address this conflict, each of the separate opinions did. The dissenting opinion stated that *Hughes* was "clearly being overruled by the majority," 833 F.2d at 941. Judge Nies asserted that "[n]o precedent is overruled or even modified by the majority opinion," 833 F.2d at 949, and that the "*Hughes* panel could not and did not depart from [element-by-element analysis]" which she states was very clearly established precedent at that time, 833 F.2d at 953. Judge Newman asserted

an apparatus that sorted items, such as fruit, by color or weight. The patent owner alleged that sorters manufactured by defendant infringed its patent under the doctrine of equivalents. *See id.* at 933-34. The Federal Circuit held that defendant's sorter did not infringe the patent because the plaintiff had failed to establish the " 'presence of every element or its substantial equivalent in the accused device.' " *Id.* at 935 (quoting *Lemelson v. United States*, 752 F.2d 1538, 1551 (Fed.Cir.1985)). In particular, the Federal Circuit rejected the argument that computer technology contained in the accused devices was equivalent to hard-wired circuitry described in the patent. The court relied heavily on limitations in the original patent requiring the device to track the position of the object being sorted, coupled with its conclusion that "the accused machine had no component which satisfied either of [those] limitations." *Id.* at 937.

The government—characterizing the analysis of the *Hughes* panel as an "invention as a whole" approach—contends that *Pennwalt*'s emphasis on the need to consider whether the accused device satisfies each limitation (or element) of the original patent dramatically undercuts the analysis of the Federal Circuit's earlier analysis of the Williams patent in

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that the majority "dealt a conspicuous change to a major jurisprudence in patent cases," 833 F.2d at 954. *See* Robert P. Merges & Richard R. Nelson, *On the Complex Economics of Patent Scope*, 90 Colum.L.Rev. 839, 858 n. 84 (1990) (asserting that *Pennwalt* overruled the "invention as a whole" approach). *But see* Martin J. Adelman & Gary L. Francione, *The Doctrine of Equivalents in Patent Law: Questions that Pennwalt Did Not Answer*, 137 U.Pa.L.Rev. 673, 700 (1989) ("[W]e see no basis for distinguishing between expanding a claim as a whole and expanding it by individual elements.").

Hughes. Hughes, on the other hand, argues that *Pennwalt* is fully consistent with the *Hughes* opinion. For two reasons, we doubt that the tension between the opinions is as significant as the government suggests. First, the *Hughes* opinion itself based its finding of infringement in large part on its conclusion, discussed above, that the store and execute spacecraft contained the substantial equivalent of each of the limitations in the Williams patent. Second, the majority opinion in *Perkin-Elmer Corp. v. Westinghouse Electric Corp.*, 822 F.2d 1528 (Fed.Cir.1987), on which the *Pennwalt* majority relied heavily for its articulation of the element-by-element approach, expressly stated that its analysis was consistent with the analysis of the *Hughes* panel. *See Perkin-Elmer Corp.*, 822 F.2d at 1532-33 (noting that the *Hughes* "infringement as a whole" analysis was a "recognition that, in applying the doctrine of equivalents, each limitation must be viewed in the context of the entire claim"). The government does not suggest that any decision of the Federal Circuit has expressed a contrary understanding of the current viability of the *Hughes* decision. In any event, as the remainder of this part of the opinion shows, it is our view that neither Galileo nor the AE spacecraft infringes the Williams patent even under the allegedly more lenient analysis of the *Hughes* panel. Accordingly, the government suffers no prejudice from our reluctance to conclude that the Federal Circuit's more recent decisions have rejected the analysis of the *Hughes* panel.

C

Although Hughes acknowledges that Galileo does not literally infringe the Williams patent, Hughes

contends that Galileo infringes the patent under the doctrine of equivalents. In Hughes' view, the only difference between Galileo and Williams is that Galileo performs calculations on board that Williams taught to be performed on the ground. Accordingly, Hughes contends, the difference between Galileo and Williams is only an increased level of sophistication made possible by advances in computer technology.

According to the government, Galileo does not contain even the substantial equivalent of clauses (f) and (g) so that the patent is not infringed whether the accused device is considered as a whole or under the element-by-element analysis.

At the outset, we note that the proper inquiry is whether claim 1 of the Williams patent reads on Galileo. That inquiry does not involve a comparison between Galileo and the adjudicated infringing devices, namely the "store and execute" spacecraft. *See Amstar Corp. v. Envirotech Corp.*, 823 F.2d 1538, 1545 (Fed.Cir.1987). We conclude that the differences between Galileo and claim 1 of the Williams patent are not limited to the location at which certain operations are performed. Instead, the function, way and result in which Galileo precesses are fundamentally different from those of the Williams patent.

As noted above, the determination of the scope of the claims made by a patent is a matter of law. Accordingly, we start in this case from the Federal Circuit's description in *Hughes* of the function, way and result of the Williams patent:

> The S/E spacecraft and the claimed Williams satellite reflect the precise circumstance envisaged in *Graver, supra*, for they perform the same function (*receipt of and response to command*

> *signals from an external location to accomplish precession*), in substantially the same way (*jet firings synchronized, albeit later and internally, with ISA position*) to obtain substantially the same result (*controlled precession of spin axis in a predetermined direction to orient a hovering satellite*).

717 F.2d at 1366 (emphasis added).

Function.—Focusing first on the function, we note that *Hughes* contemplated the sending of a "command signal" from ground control. In performing the commanded turn maneuver, the only information sent from ground control to Galileo that is relevant for attitude control is the desired orientation. All subsequent calculations related to attitude control are performed by the on-board computers that are programmed and installed before launch. In fact, once the maneuver begins, ground control loses contact with the spacecraft. In contrast, it is basic to the operation of Williams that ground control generate signals that tell the spacecraft where in the spin cycle and how many times the jet must be pulsed to precess. Ground control does not lose contact with the spacecraft once the maneuver begins, and, in fact, constantly monitors the progress and sends additional firing signals.

In our view, the *Hughes* opinion teaches that the function of Williams is the receipt and response to specific firing commands, not directional coordinates. That function is not reproduced on Galileo. The mission of Galileo requires it to be largely autonomous, and, as part of that autonomy, computers generate all jet firing command signals on board the spacecraft. It is true that both require some sort of

signal from the ground to initiate precession. The Federal Circuit has made clear, however, that the range of equivalents to be accorded to Williams is not broad enough to cover all ground controllable spacecraft. *Hughes*, 717 F.2d at 1363. If the general command signal required by Galileo were covered, then Williams would extend in practice to any type of ground control signal. Because we find that result inconsistent with the Federal Circuit's analysis in *Hughes*, we find that the type of commands transmitted by ground control substantially distinguishes the functions of Williams and Galileo.

Way.—The differences between Williams and Galileo are perhaps most marked concerning the "way" in which each accomplishes precession. We conclude that there are numerous conceptual differences between Williams and Galileo that are far greater than a simple change of the location at which various calculations are performed. We summarize three somewhat overlapping differences here.

First, the use of a different type of reference to fix the place in the spin cycle in which the precession jets will fire shows that the manner in which Galileo and Williams accomplish precession is not substantially equivalent. Galileo, unlike Williams, does not calculate a time delay or angle delay from a reference. When discussing whether angle-based systems infringed Williams, we noted that "the essence of the precession system [in both the time-based and angle-based systems] is the firing of the thrusters at a certain point after the sun pulse" (Tr. 17,191). Instead, Galileo uses a gyroscope and tick marks, both of which are mounted on the despun section of the spacecraft, to align the scan platform with the turn plane. Although we are not persuaded that a

gyroscope-based system cannot be covered by the Williams patent (because it substitutes an internal reference point for the external reference point described in the Williams patent,[16] we do conclude that the way in which the gyroscope is used here makes Galileo fundamentally different from the device described by Williams.

The laws of physics dictate the direction in which a spinning spacecraft will precess given the point in the spin cycle at which the precession jet is fired. The corollary of this is that in order to precess in the proper direction, a spinning spacecraft must fire its precession jets at a particular point in its spin cycle. Because prior art (the McLean Space Vehicle) had included a method of using an angle between the target and the spin axis as a reference to trigger firing, the Williams patent cannot cover all devices that rely on that principle. As construed by the Federal Circuit in *Hughes*, the particular way covered by the Williams patent is a way of precessing by use of a time or angle delay from an external reference, namely a sun pulse. By relying on physical marks on the spacecraft coupled with a gyroscope to determine the appropriate firing point, Galileo reflects a different way of accomplishing the desired precession.[17]

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[16] Compare Tr. 7487-88 (testimony that gyroscope is fundamentally different) with Tr. 15451-52, 15514-17 (testimony that gyroscope in fact provides an external reference).

[17] When asked whether Galileo's on-board computers performed the same calculations that were previously done on the ground, one of Hughes' expert witnesses, Hibbs, responded that the "same type" of calculations were performed but that Galileo essentially used "another way" of synchronizing the jet pulsing (Tr. 15512).

Second, the ability of Galileo to see its target enables it to travel the shortest route. Both Williams and Galileo precess at a 90 degree angle from the direction the pulsing occurs. Galileo, which knows where its target is, always pulses at a 90 degree angle to the target direction. By doing so, Galileo is able to precess directly in its target direction, i.e., it travels a great-circle path (Tr. 7637-38, 15,467). In contrast, in Williams where the system cannot see the target and the sun is used as the reference, the time delay following the sighting of the reference is variable and must be computed by ground controllers. As a result, the Williams system travels in a spiral path, or rhumb line. Accordingly, Galileo travels the shortest possible route and minimizes fuel use (Tr. 15,467).

Finally, the two processes of determining that a spacecraft has precessed to the desired orientation are different. In Williams, ground control pre-computes the position in the spin cycle in which the jets should be fired and the number of times the jet should be fired. Ground control then monitors the precession by using an oscilloscope. If the spacecraft does not reach the desired orientation, ground control sends additional command signals. In contrast, Galileo's error nulling system does not depend on the precomputation of these factors, in which there is always a degree of uncertainty.

Result.—The last part of the *Graver* tripartite test, that is, whether the results of Galileo and Williams are equivalent, is a closer question. *Hughes* defines the result of Williams as the "controlled precession of [the] spin axis in a predetermined direction." *Hughes*, 717 F.2d at 1366. We note that there are at least two differences in the results achieved by Galileo and Williams. First, the error nulling func-

tion of Galileo permits it to achieve a greater degree of accuracy (Tr. 7478). Second, the great circle path traveled by Galileo permits greater fuel efficiency. Although those differences are not dramatic, they also tend to support a finding of noninfringement.

In sum, we conclude that the fact that Galileo is essentially a closed-loop system that only receives a target direction from ground control renders its function fundamentally different from the function of Williams. And further, even if the movement of all functions on board except for the transmission of a target direction could be considered insufficient to avoid equivalence with Williams, the evidence shows that the way in which precession occurs on Galileo is quite different from—and thus not at all equivalent to—the way in which precession occurs on a Williams spacecraft. Lastly, we conclude that even the results achieved by Williams and Galileo are so different that Galileo cannot be considered equivalent to Williams.

In closing, we reject Hughes' general contention that even if Galileo contains improvements that may be patentable in themselves, it still relies on basic teachings of Williams and thereby infringes under the doctrine of equivalents. It is true that Galileo is much more sophisticated than Williams and performs on board, by use of computers, many functions that Williams performed on the ground. Yet, for the reasons summarized above, we conclude that Galileo's attitude control system, rather than being an improvement on Williams, is an entirely *different* system. At bottom, Galileo's design does not merely replace features described in Williams with improved features; it eliminates them entirely as unnecessary in light of the wholesale differences in the overall

design of the attitude control system. Accordingly, Galileo does not infringe the Williams patent.

D

Hughes also contends that the AE spacecraft infringed Williams under the doctrine of equivalents. The government has articulated three reasons for its contention that AE does not infringe. Two of these reasons have been decided in Hughes' favor. First, we rejected the notion that AE's 63 degree canted thruster was not substantially parallel as required by clause (d) for purposes of infringement under the doctrine of equivalents (Tr. 17,153- 57). Second, we rejected the suggestion that angle-based systems could not infringe Williams (Tr. 17,189-91).

The government's remaining argument is that AE was unique among angle-based systems because the pulsing was not keyed to occur at a given angle relative to an external reference. The system was not as autonomous as Galileo, and thus the decision regarding equivalence is a closer one. In particular, the evidence at trial did not establish any of the pronounced differences in the way and result discussed above with respect to Galileo. Nonetheless, in our view the function of the AE spacecraft differs sufficiently from that of the device invented by Williams to avoid infringement.

As stated above, the Federal Circuit in its 1983 decision in *Hughes* held that the function of the Williams spacecraft was to receive and respond to command signals from an external location to accomplish precession. Significantly, the only information sent from the ground controllers to the spacecraft was the start and stop time for the yaw maneuver. With that information, the spacecraft per-

formed all functions required to precess. Other than the fact that AE used earth sensors as an external reference to accomplish precession, and in that respect is much more similar to Williams than is Galileo, the attitude control system of AE operated quite differently from both Williams and the store and execute spacecraft that have been adjudicated to infringe the patent. In both Williams and the store and execute spacecraft, ground controllers use information obtained from sun sensors to determine the appropriate number of pulses and in what portion of the spacecraft's spin cycle the jets are to be activated in order to achieve a desired new orientation. Those operators then issue commands directing the firing of the spacecraft's precession jets. In Williams, the spacecraft receives real-time firing signals that ground control has coordinated with the spin cycle. In the store and execute system, the spacecraft receives a signal to fire after a given time or angle delay from a sun pulse that is also coordinated with the spin cycle. In contrast, in AE, the only information sent from ground control to the spacecraft—the start and stop time—had nothing to do with the position in the spin cycle in which pulsed firing should occur (Tr. 8393). The synchronization in both the Williams "real time" spacecraft and the "store and execute" spacecraft is accomplished by ground personnel, who calculate when the jet pulses must be fired relative to the sun pulses in order to achieve the desired precession. In AE, that calculation was performed by spacecraft's on-board computer.

Admittedly, the Federal Circuit's decision regarding the store and execute spacecraft held that the advances in computer technology presented there did not allow the spacecraft "to escape the 'web of

infringement.'" 717 F.2d at 1365 (quoting *Bendix Corp. v. United States*, 220 Ct.Cl. 507, 537, 600 F.2d 1364, 1382 (1979)). Essentially, the difference between AE and Williams is one of advancements in computer technology. Nonetheless, the Federal Circuit made clear that the range of equivalents to be accorded to the Williams patent was limited. The patent does not cover all ground controllable spacecraft nor all spin-stabilized spacecraft that precess by way of jet pulsing. In particular, the court emphasized that the attitude control system invented by Williams depended on some type of ground control participation. In our view, the computer technology at issue here is different, because it so limits the role of ground control in determining the nature of the attitude thruster firings as to make it implausible to suggest that the spacecraft falls within the limitations of the invention described by Williams.

This is particularly evident when one refers to the precise claim made by Williams. A central focus of clauses (e), (f) and (g) (quoted in Part II) is the delivery of information to the ground, coupled with the receipt from the ground of signals directing firings at a ground-determined point in the spin cycle. The AE spacecraft do not contain anything that fairly can be characterized as the substantial equivalent of those limitations.

As the Federal Circuit has explained, although "a 'non-pioneer' invention may be entitled to some range of equivalents, a court may not, under the guise of applying the doctrine of equivalents, erase a plethora of meaningful structural and functional limitations of the claim on which the public is entitled to rely in avoiding infringement." *Perkin-Elmer Corp. v.*

Westinghouse Elec. Corp., 822 F.2d 1528, 1532 (Fed.Cir.1987). The Federal Circuit emphasized:

> Though the doctrine of equivalents is designed to do equity, and to relieve an inventor from a semantic strait jacket when equity requires, it is not designed to permit wholesale redrafting of a claim to cover non-equivalent devices, i.e., to permit a claim expansion that would encompass more than an insubstantial change.

Id. To erase the element of ground control found in clauses (e), (f) and (g) of the patent would involve such "wholesale redrafting." As discussed above, we see no basis in the *Hughes* opinion for ignoring the language of those limitations. Accordingly, we conclude that the AE spacecraft do not infringe the Williams patent under the doctrine of equivalents.

IV

This portion of the opinion addresses the liability issues associated with the alleged unlawful use or manufacture for the government of 14 Global Positioning System (GPS) spacecraft, specifically GPS 22 and 24 through 36.[18]

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[18] Initially, plaintiff accused all 40 spacecraft in the GPS program. (See Appendix to Opinion for complete list.) With respect to 17 GPS spacecraft, the government conceded claim readability and use prior to the January 1991 trial phase. Of the remaining 23 GPS satellites, nine are no longer in issue. The government conceded liability for five of those spacecraft, namely GPS 15, 18, 20, 21 and 23. As of the expiration date of the Williams patent, each of those spacecraft had either been launched or was ready to be launched as soon as facilities became available. In addition, plaintiff conceded that four of the spacecraft, namely, GPS 37 through 40, had not been "manu-

Defendant acknowledges that the GPS spacecraft are designed to contain an attitude control system that uses the Williams patent. *See* Appendix to Opinion n. 12. Defendant maintains, however, that certain of the GPS spacecraft were not manufactured or used by its contractor with its authorization or consent within the life of the patent and therefore did not infringe the Williams patent.

A

The GPS ("Global Positioning System") family of spacecraft is part of a navigation system designed to provide users with precise three-dimensional position, velocity and time information. In addition to their use for navigation, the GPS spacecraft carry a payload capable of detecting nuclear detonations.

The GPS system consists of 18 spacecraft orbiting the earth simultaneously in six different orbits, with three spacecraft in each orbit. The GPS spacecraft use both the Williams' spin-stabilized attitude control system and a full-body attitude control system. The spin-stabilized system is used in reaching final orbit. Once the spacecraft has reached final orbit, the spacecraft is despun and the full-body system is employed thereafter to orient the spacecraft. Nonetheless, the spin-stabilized system is always available as a backup attitude control system. Thus, if the full-body attitude control system fails during the life of the spacecraft, the spacecraft can be spun up again and the spin-stabilized system used to reorient the spacecraft.

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factured" as of the expiration date of the patent. *See* Appendix to Opinion.

B

Rockwell International Corporation designed and built the GPS spacecraft under a procurement contract with the government. Rockwell's organizational structure for the GPS program divided responsibility for the project among eight program components. Two of those components were Systems Installation and Testing. Systems Installation was responsible for installation of the electronics and physical assembly of the spacecraft. Once the spacecraft was completed and inspected, the spacecraft was sent to Testing. Testing assured that the spacecraft functioned properly in normal conditions and in a simulated outer-space environment (Tr. 18,988).

The sequence of testing that an assembled GPS spacecraft experienced is as follows. The first test, the Ambient Functional Test, verified the functionality of the individual subsystems and the functionality of the entire spacecraft assembly.[19] The second test, the Thermal Cycle Test, exposed the spacecraft to extreme temperatures to simulate the environment of outer space. The third test, the Acoustics Test, exposed the spacecraft to different levels of vibration. The fourth test, the Thermal Vacuum Test, exposed the spacecraft to extreme temperatures and a vacuum. The fifth test, the Final Factory Processing Test, included a spin test to verify the balance of the spacecraft, a post-thermal vacuum test to verify the spacecraft's operability after the thermal vacuum test and a final factory functional test to ensure that the entire spacecraft operated properly. Tr. 19,005-06.

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[19] For a description of the approximately 30 steps involved in that test, see Tr. 19,080-101.

All of these tests were performed in accordance with Military Standard 1540, which specifies that a "full-up" space vehicle must be the object of these tests (Tr. 19,066).

The spacecraft were assembled and tested in incremental stages. The GPS assembly sequence began with assembly of the various structural elements that form the core of the spacecraft. Next, the wire harness and reaction control system were installed. Then the other systems, including electrical power, telemetry tracking and command, attitude control, velocity control and payload, were installed. Finally, the orbit insertion system was installed. Tr. 19,185-87. Before each subsystem was installed, it was tested individually (Tr. 19,200).

Between Systems Installation and Testing, the Defense Contract Manufacturing Area Office, acting on behalf of the government, conducted an "ITI 3201 Inspection" to ensure that systems installation was complete.[20] Government representatives, using aids such as flashlights, mirrors and magnifiers, inspected the spacecraft's structure, as well as a variety of the individual components such as the electrical wire harness, thermal blanket insulation, optical sensors, coaxial cables, black boxes, RCS propellant tanks and lines, L band antenna mast, RCS thruster assembly and reaction wheel assemblies (Tr. 19,067-74). At that point, the Testing group subjected the assembled spacecraft to the sequence of tests described above. Each of those tests was designed to ensure that the assembled spacecraft could perform its mission.

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[20] The title of the ITI inspection form reads "Systems Installation Complete, pre-turnover, Manufacture to Test Operations" (PX 3018.193).

As of September 11, 1990 (the date the Williams patent expired), each of the 14 GPS spacecraft at issue had completed Systems Installation and passed ITI 3201 Inspection (PX 3018.417); thus, each of those spacecraft had been assembled and inspected and was ready to be extensively tested. Further, as of September 11, 1990, each of the 14 GPS spacecraft at issue had begun the testing sequence described above (PX 3018.417; PX 3018.6). In fact, 13 of those spacecraft had completed the ambient functional test (PX 3018.417). (GPS 36 was undergoing that test when the patent expired (PX 3018.6)). As described above, that test verifies the reliability of both the individual subsystems and the spacecraft assembly. The spacecraft's power is turned on, and the spacecraft then proceeds through a series of possible commands. Each of the subsystems is tested to make sure that it functions individually as well as in connection with the entire system. The attitude control system is thoroughly tested to ensure that it functions properly. Upon successful completion of the ambient functional test, engineers know that the spacecraft has been assembled securely and is functioning correctly. In addition, several of the spacecraft at issue had undergone some of the environmental tests (PX 3018.417).

C

Section 1498(a) of title 28, United States Code, provides in part:

> Whenever an invention described in and covered by a patent of the United States is *used or manufactured by or for the United States* without license of the owner thereof or lawful right to use or manufacture the same, the owner's remedy shall

> be by action against the United States in the United States Court of Federal Claims for the recovery of his reasonable and entire compensation for such use and manufacture.
>
> For the purposes of this section, the use or manufacture of an invention described in and covered by a patent of the United States by a contractor, a subcontractor, or any person, firm, or corporation for the Government and with the authorization or consent of the Government, shall be construed as use or manufacture for the United States.

(Emphasis added). The words "manufacture" and "use" in § 1498 (as well as the words "make," "use" and "sell" in Title 35) have never been defined by Congress and have become a matter of judicial interpretation.

Although the government acknowledges that each of the 14 GPS spacecraft in issue were designed to incorporate the Williams patent, the government contends that none of these spacecraft were used or manufactured during the patent term within the meaning of § 1498(a). As part of this argument, defendant maintains that any manufacture or use by Rockwell was not with the authorization or consent of the government. We conclude that each of the spacecraft in issue was manufactured by Rockwell for the United States during the patent term with the authorization of the government. Consequently, we find that each of the 14 spacecraft should be included in the compensation base.

1.

First, we address the government's contention that none of these spacecraft were manufactured or used

during the term of the patent. The leading Federal Circuit case addressing the meaning of the terms "make"[21] and "use" in this context is *Paper Converting Machine Co. v. Magna-Graphics Corp.*, 745 F.2d 11 (Fed.Cir.1984). *Paper Converting* involved a patent for an automatic rewinder used in the manufacture of rolls of densely-wound industrial toilet tissue and paper towels. According to the Federal Circuit, the machine operated as follows:

> First, from within a 72-inch long "cutoff" roll, a 72-inch blade ejects to sever the continuous web of paper which is wound around the bedroll. Then, pins attached to the bedroll hold the severed edge of the web while pushers, also attached to the bedroll, transfer the edge of the web towards the mandrel (the roll on which the paperboard core is mounted).

Id. at 15. In order to avoid infringement liability, defendant tested and shipped parts of the machine without fully assembling it before the patent expired. Instead of testing the fully completed assemblies before shipment, defendant conducted two separate tests. In the first test, defendant checked the bedroll to determine whether the pushers actuated properly. During that test, no cutoff blades or pins were

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[21] The parties do not suggest that the word "manufacture" in § 1498 should have a meaning different from the meaning of the term "make" that appears in the analogous provision of the patent statute, 35 U.S.C. § 271. Although the parties cite no case holding that the terms should have an identical meaning, we see no basis for treating the terms differently in this case. Accordingly, we rely in this section on cases interpreting the term "make" in Title 35 to assist us in interpreting the term "manufacture" in § 1498.

installed. In the second test, defendant checked the cutoff roll to determine whether the blade actuated properly. In that test, no pins or pusher pads were installed. Then, pursuant to an agreement with its purchaser, defendant shipped the basic machine and the cutoff roll and bedroll in separate packages. The machine was fully assembled and installed after the patent expired.

The Federal Circuit held that the testing of significant assemblies to the extent that an infringer would have confidence in the operability of the completed patented device constituted infringement. *Id.* at 19-20. In effect, the court held that defendant's actions constituted a "use" of the patent. The court framed the issue as "the extent to which a competitor of a patentee can *manufacture* and test during the life of a patent a machine intended solely for post-patent use." *Id.* at 16 (emphasis in original). The court recognized the potential unfairness that may arise if liability cannot attach before a device is completely assembled and tested. In concluding that neither complete assembly nor complete testing was necessary to find infringement, the court declared that the fact "[t]hat the machine was not operated in its optimum mode is inconsequential: imperfect practice of an invention does not avoid infringement." *Id.* at 20. The court reasoned that "a contrary result would emasculate the congressional intent [of preventing] the making of a patented item during the patent's full term of 17 years" and create a climate in which "[n]othing would prohibit the unscrupulous competitor from aggressively marketing its own product and constructing it to all but the final screws and bolts." *Id.* at 19.

The Federal Circuit distinguished the Supreme Court's decision in *Deepsouth Packing Co. v. Laitram Corp.*, 406 U.S. 518, 92 S.Ct. 1700, 32 L.Ed.2d 273 (1972). *Deepsouth* involved a patent covering a shrimp deveining machine. The defendant had partially assembled the device in the United States and then shipped the partial assemblies overseas for final assembly. At that time, the relevant patent statute, 35 U.S.C. § 271, provided that "whoever without authority makes, uses or sells any patented invention, *within the United States* during the term of the patent" infringes the patent[2] (emphasis added). The Supreme Court held that selling subassemblies of a combination patent with the intent that the buyer would combine the parts in a foreign country did not constitute infringement. *Id.* at 532, 92 S.Ct. at 1708. The Court reasoned:

> We cannot endorse the view that the "substantial manufacture of the constituent parts of [a] machine" constitutes direct infringement when

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[2] In 1984, Congress amended the patent laws to reject the result in *Deepsouth* by adding an additional type of infringement. *See* 1984 U.S.C.C.A.N. 5827-28. Section 271(f)(1) of title 35, United States Code, now provides:

> Whoever without authority supplies or causes to be supplied in or from the United States all or a substantial portion of the components of a patented invention, where such components are uncombined in whole or in part, in such manner as to actively induce the combination of such components outside of the United States in a manner that would infringe the patent if such combination occurred within the United States, shall be liable as an infringer.

It is worth noting that the amendment neither defined the terms "make," "use" or "sell" nor overruled *Deepsouth's* interpretation of those terms.

> we have so often held that a combination patent protects only against the *operable assembly of the whole* and not the manufacture of its parts.

Id. at 528, 92 S.Ct. at 1707 (emphasis added).

The Federal Circuit in *Paper Converting* argued that its decision finding infringement based on incomplete assembly was consistent with *Deepsouth* for two reasons. First, it argued "that *Deepsouth* was intended to be narrowly construed as applicable only to the issue of the extraterritorial effect of the American patent law." 745 F.2d at 17. Second, it asserted that the Supreme Court's reference to an operable assembly of the whole "probably [would include] something short of a full and complete assembly." 745 F.2d at 18.

There unquestionably is a significant tension between the analysis of the Federal Circuit in *Paper Converting* and the analysis of the Supreme Court in *Deepsouth*. As judges and commentators have noted, it is plausible to understand the Court in *Deepsouth* as holding that the term "make" was not satisfied by the manufacture of three separate assemblies that would infringe a patented apparatus when they were assembled in a process that would take less than an hour.[23] Although the briefs of the parties debate this

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[23] Judge Nies dissented in *Paper Converting*, asserting that "[t]he majority's conclusion necessitates giving a meaning to 'patented invention' contrary to the definition set forth by the Supreme Court in *Deepsouth*." 745 F.2d at 24. For similar observations, *see De Graffenried v. United States*, 25 Cl.Ct. 209, 214 (1992) (holding that Paper Converting provides a narrow exception to the general rule in *Deepsouth*); J. Dwyer Murphy, Note, Paper Converting Machine Company v. Magna-Graphics Corporation: *Increased Protection Against Making and Using Combination Patents*, 34 Am.U.L.Rev. 761, 773-78 (1985) (argu-

question in some detail, we have no occasion to resolve that tension. We conclude that the state of the 14 GPS spacecraft in issue when the Williams patent expired was such that the spacecraft would be found to have been manufactured on that date under either the *Paper Converting* analysis or the *Deepsouth* analysis.

A few preliminary observations illustrate the boundaries of the problem. The issue of whether a device has been "manufactured" for purposes of the patent laws is a mixed question of law and fact. A patentee cannot lengthen the term of his patent by receiving compensation for devices that are not in fact "manufactured" or "used" during the patent term. Conduct falling short of manufacture, even if it capitalizes on the patent in some sense, does not constitute infringement. *See Tektronix, Inc. v. United States*, 216 Ct.Cl. 144, 152, 575 F.2d 832, 837 (holding that the execution of a contract to manufacture infringing devices did not constitute infringement), *cert. denied*, 439 U.S. 1048, 99 S.Ct. 724, 58 L.Ed.2d 707 (1978). On the other hand, the question of whether a device has been manufactured cannot depend on whether the alleged infringer deems the accused device to be ready for use. *See Paper Converting*, 745 F.2d at 19-20. To interpret the term "manufacture" that narrowly would subject the patent laws to manipulation and unfairly deprive the patentee of the benefits of the 17-year term of its patent.

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ing that *Paper Converting* "contravened the still valid rule of *Deepsouth* that only a combination in final operable assembly constitutes a making").

The government contends that the spacecraft in issue were not manufactured as of the expiration date of the patent for two separate reasons. First, the government maintains that the spacecraft were not physically assembled by the expiration date because certain flight components had not been integrated into the spacecraft either because the details of the spacecraft's design had not been finalized or because the parts were unavailable. Second, the government maintains that even if the spacecraft were completely assembled as of the expiration date they had not been "manufactured" in the statutory sense because they had not been completely tested by that date.

On the first point, the government does not disagree with Hughes' allegation that each of the spacecraft in issue had completed "systems installation" as of the expiration date. As we noted above, systems installation is the final assembly stage during which all of the components, subsystems and systems ordinarily would be installed. Nonetheless, components of the spacecraft frequently were missing even after the completion of systems installation. One of Hughes' witnesses accurately summarized the true state of affairs when he explained that by the completion of systems installation "the spacecraft has been assembled to the extent of the available components" and is considered to be "in an acceptable configuration to start the testing process" (Tr. 19,005). When a spacecraft that was missing a component proceeded to testing, that component would be added during one of the testing phases. Hence, we accept the government's point that the fact that each of the spacecraft in issue had completed systems installation as of the expiration date does not neces-

sarily mean that the spacecraft were *completely* assembled.

The government contends that the missing components prevented the spacecraft from being bodies adapted to spin about axes, as required by clause (a) of claim 1 of the Williams patent. The record indicates, however, that as of the expiration date of the patent, the contractor had dealt with each of the parts missing at the time systems installation was completed either by inserting a final part, or by inserting a test part. The test parts would not have been used when the spacecraft was launched and, in many cases, were inoperable "dummy" parts included only to give the spacecraft the appropriate mass and balance during the testing process. Tr. 19,234-42, 19,113-23; PX 3018.417. Hughes points out that the missing components did not prevent the spacecraft from being tested for operability and contends that the use of test components satisfied the requirements of the patent because they provided the required mass. The government argues that the use of "dummy" parts does not suffice because *Deepsouth* requires that all elements of the claim be constructed into an "operable assembly." Because dummy parts are not intended to be launched into space, the government reasons, their inclusion on the spacecraft renders the spacecraft inoperable.

We are not persuaded by the government's argument. Even though test parts were not intended to be launched with the spacecraft, the fact remains that the spacecraft, including the attitude control system, had been entirely assembled to the extent feasible at the time. In our view, that complete physical assembly readily satisfies *Deepsouth's* requirement of an "operable assembly of the whole," 406 U.S. at 528, 92

S.Ct. at 1707. This holding is buttressed by our earlier ruling that the manufacture of a qualification test vehicle can constitute infringement. We stated that

> the construction of that qualification test vehicle, whether that's all it was ever intended to be and all it ever became up to the present or whether it was later refurbished and became a flight vehicle, my ruling is that a separate taking can occur under [28 U.S.C. §] 1498 when a qualification test vehicle has been manufactured that incorporates the patented device.

Tr. 16,969. In our view, the most important point is that by the time the patent expired the spacecraft with test components had become bodies adapted to spin about axes that satisfied all the claims of the Williams patent. Accordingly, those spacecraft were "manufactured" for purposes of § 1498 by that date.

The government attempts to avoid that conclusion by noting that even if each of the spacecraft had been assembled to the extent to which they were intended to be as of completion of systems installation, there were still some components that had not been integrated. Specifically, the government argues that because the fuel and flight batteries were added at later stages, and because the thrusters were not wired until later stages, the spacecraft were not manufactured as of the expiration date of the patent. We disagree. With respect to fuel, the government's construction reads too much into the word "manufacture" because it almost equates "manufacture" with "use." Even *Deepsouth's* construction of "make" does not suggest that an item such as fuel would be a part of the making. Under the govern-

ment's interpretation, a radio would not be made until batteries were added or a power cord was plugged into a socket. Similarly, we do not view the use of a test battery, which is not actually mounted on the spacecraft, as opposed to a flight battery, or the fact that the thrusters were not wired until right before launch, as undermining our conclusion that the 14 spacecraft had been manufactured as of the expiration date of the patent. Even without those final touches, the spacecraft constituted completely assembled objects that incorporated the invention reflected in the Williams patent.

The government's final contention pertaining to its incomplete assembly argument is that some components were found to be defective during the testing process and had not been replaced as of the expiration date of the patent. We reject that contention because it assumes that a device has not been manufactured at any point in time when one of its components is not functioning properly. Under that reasoning, a spacecraft that malfunctioned after launch would at that time become a spacecraft that had not yet been manufactured. Such reasoning neither comports with the ordinary meaning of the word "manufacture" nor finds support in any of the case law. Accordingly, we conclude that the spacecraft were physically assembled by the expiration date of the patent to the point that they constituted operable assemblies as contemplated by *Deepsouth*.

The government's second basis for asserting that the spacecraft had not been "manufactured" relies on the fact that the full testing process (i.e., the series of five tests to insure readiness for a space environment) was not complete on any of the spacecraft in issue by the expiration date. The importance of test-

ing to these spacecraft cannot be overstated. There were four purposes of the GPS testing program: the minimization of infant mortality,[24] the detection of workmanship and material deficiencies, verification that performance meets specified requirements and demonstration that the vehicle is acceptable for delivery (DX 4607H). Testing represented a substantial portion of the total time expended in performing the contract and the total cost of the contract (Tr. 19,721, 20,185). Further, it is almost, if not entirely, impossible with current technology to build an apparatus as complex as a GPS spacecraft without some manufacturing defects (Tr. 19,714). The record shows that components failed during each phase of the testing process (Tr. 19,705-07). Moreover, once a spacecraft has been placed in orbit the cost of repairing it at that stage is prohibitive. Accordingly, based on each of those factors, the government argues that a GPS spacecraft is not an operable assembly before the testing is completed because before that time it is highly unlikely that it would operate as intended.

This point has the most force with respect to the spin test; the government argues that until that test has been completed, the spacecraft is not adapted to spin about an axis and thus does not satisfy clause (a) of the Williams claim. The government points out that the spin test does more than simply confirm that the body spins around the appropriate axis. Instead, the test typically results in the addition of balance

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[24] In this context, "infant mortality" refers to the phenomenon that certain components of the spacecraft experience significantly high rates of failure during the early stages of their use.

weights that perfect the balance of the spacecraft. DX 4607H.

Despite the importance of testing, we do not view the function of the tests in issue (all post-assembly and post "ITI 3201" inspection) to be a part of the manufacturing process. The ordinary usage of the term "make" within this context is "to create by putting together component parts." Webster's II New Riverside University Dictionary 718 (1984). (Similarly, "manufacture" is defined as "to make or process (a raw material) into a finished product," *id.* at 725.) Synonyms for "make" are "assemble," "build," "construct" and "fabricate." *Id.* at 719. *See also Bauer & Cie v. O'Donnell*, 229 U.S. 1, 10, 33 S.Ct. 616, 617, 57 L.Ed. 1041 (1913) ("The right to make can scarcely be made plainer by definition, and embraces the construction of the thing invented."). To define the term "manufacture" as "make ready to accomplish the intended mission" nearly obliterates the distinction in § 1498 between "use" and "manufacture." These tests—however important—are not part of the process of assembling or fabricating the accused object; that process is completed, at the latest, when the spacecraft complete systems installation. The tests at issue here are part of a later process for perfecting the ability of the object to perform its intended use. Those tests simply do not fall within any fair usage of the term "manufacture." In sum, we conclude that each of the 14 GPS spacecraft in issue was "manufactured" as of the expiration date of the patent.[25]

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[25] As an alternative to its argument pertaining to "manufacture," the plaintiff asserts that the testing of these spacecraft constituted "use." Plaintiff relies on cases holding that

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Having determined that Rockwell "manufactured" the accused spacecraft before the patent expired, we address the government's contention that the "manufacture" was not "for the Government" because the government had not "authorized" or "consented" to the "manufacture" within the meaning of § 1498(a).

The government argues that an authorization and consent clause contained in its contract with Rockwell limited the government's authorization or consent until it "accepted" the spacecraft. That clause provides, in part:

> The Government hereby gives its authorization and consent (without prejudice to any rights of indemnification) for all use and manufacture, in the performance of this contract . . . of any invention described in and covered by a patent of the United States (i) *embodied in the structure or composition of any article the delivery of which is accepted by the Government under this contract*, or (ii) utilized in the machinery, tools, or methods the use of which necessarily results from compliance by the Contractor or the using subcontractor with (a) specifications or written provisions now or hereafter forming a part of this

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testing can be a "use." *See Roche Prods. Inc. v. Bolar Pharmaceutical Co.*, 733 F.2d 858, 861 (Fed.Cir.) (holding that testing of a patented drug for purposes of FDA approval regulations constituted "use"), *cert. denied*, 469 U.S. 856, 105 S.Ct. 183, 83 L.Ed.2d 117 (1984). Although we agree that defendant did in fact "use" the spacecraft in addition to "manufacturing" them, we base that conclusion on the fact that any testing that occurred after the spacecraft was "manufactured" constituted "use."

> contract, or (b) specific written instructions given by the Contracting Officer directing the manner of performance.

(Emphasis added.) As the language suggests, clause (i) addresses apparatus patents, and clause (ii) addresses method patents. Accordingly, clause (i) is relevant here.

The government asserts that this clause means that the government has not authorized use of the patent until it accepts the object, and that acceptance does not occur until the execution of the final DD 250.[35] In response, Hughes contends that the government authorized or consented to the "manufacture" upon executing the contract that required Rockwell to infringe the Williams patent. According to Hughes, the authorization and consent clause in the government's contract with Rockwell cannot be used to limit the government's preexisting authorization. In any event, Hughes contends that the government authorized use of the Williams invention in each GPS spacecraft upon its acceptance and launch of the first spacecraft manufactured under the contract. Finally, Hughes relies on various other provisions in the

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[35] The 1983 contract between Rockwell and the government incorporated DAR § 7-104.62 which requires a contractor to furnish a "Material Inspection and Receiving Report" (DD Form 250), as specified in ASPR Appendix I, upon delivery of items under the contract (PX 3018.8). Appendix I states that DD Form 250 shall be used for delivery of contract line items and provides evidence of acceptance of those items. The contract provided that two DD Form 250's would be used for each spacecraft: (1) an "interim" form was issued to show completion of assembly of the vehicle up to the point of installation of the reaction control system and (2) a "final" form was issued to show completion of testing and delivery of the vehicle.

government's contract with Rockwell to establish that acceptance of each particular patented device occurred before the patent's expiration date.

Authorization or consent by the government can be expressed in many forms, including "by contracting officer instructions, by specifications or drawings which impliedly sanction and necessitate infringement, [or] by *post hoc* intervention of the Government in pending infringement litigation against individual contractors." *Hughes Aircraft Co. v. United States*, 209 Ct.Cl. 446, 465, 534 F.2d 889, 901 (1976). In addition, authorization or consent can be implied. *TVI Energy Corp. v. Blane*, 806 F.2d 1057, 1060 (Fed.Cir.1986). An express authorization or consent will be found where the government requires the private contractor to use or manufacture the allegedly infringing device, even if the government does not know that the device infringes a patent. *TVI*, 806 F.2d at 1060.

Accordingly, because the parties agree that the government's contract with Rockwell required Rockwell to manufacture spacecraft that embodied the Williams patent,[27] the issues are whether an "acceptance" is required to establish "authorization or consent" and whether a final DD 250 is required to establish such an "acceptance."

Because Congress has not defined the terms "authorization" and "consent," we start with the pre-

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[27] The contract by its terms required Rockwell to build a spacecraft identical to the other spacecraft it had constructed for the government at an earlier date. The government has conceded that the design of those spacecraft and the GPS spacecraft in issue incorporated the invention claimed in the Williams patent.

mise that they must be given their ordinary meanings. Putting aside for the moment the authorization and consent clause, it is clear that the government "authorized" the manufacture of the accused spacecraft when Rockwell became contractually bound to build spacecraft embodying the Williams patent. *See TVI*, 806 F.2d at 1060; *Hughes*, 209 Ct.Cl. at 465, 534 F.2d at 901. As mentioned earlier, Rockwell was obligated by its contracts with the government to construct spacecraft using the Williams design; the relevant obligations arose before Rockwell constructed the spacecraft, and thus long before the patent expired. The authorization and consent clause cannot change that result.[28] Even if the terms "authorization" and "consent" had a particular contractual meaning between Rockwell and the government, it is the statutory meaning of those terms that controls this case under § 1498, between a patentee and the government.[29] Accordingly, we conclude that

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[28] We note that the clause cannot be considered to be an agency interpretation of § 1498 that is entitled to deference. *Chevron U.S.A., Inc. v. Natural Resources Defense Council, Inc.*, 467 U.S. 837, 104 S.Ct. 2778, 81 L.Ed.2d 694 (1984), makes clear that deference to agency interpretation extends only to agencies charged with administration of the statute in question. The Department of Defense is not charged with the administration of § 1498.

[29] One case has suggested that an authorization and consent clause might limit the government's authorization or consent. However, that case, *Carrier Corp. v. United States*, 208 Ct.Cl. 678, 682-83, 534 F.2d 244, 248-49 (1976), was decided in a much different factual context. In *Carrier*, the owner of the patent was attempting to establish an authorization or consent pursuant to that clause. There were no contract specifications or instructions from the contracting officer that required the government contractor to use the accused patented device.

the requisite authorization or consent was given no later than the time at which Rockwell became contractually bound to manufacture a spacecraft containing an embodiment of the Williams patent.[30]

In any event, even if the authorization and consent clause was binding on Hughes and precluded liability until the government accepted the spacecraft, we would find the government liable because we conclude that the government had accepted the accused devices before the patent expired. First, we note that a

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Accordingly, that case does not stand for the proposition that the clause limits an authorization or consent once it is expressly given.

[30] We note that our interpretation of the statute comports with the Supreme Court's view that courts should not lightly conclude that Congress intended to deprive patentees of effective recourse for infringement simply because the infringer was the government or a party working for the government. *Richmond v. Screw Anchor Co. v. United States*, 275 U.S. 331, 344-46, 48 S. Ct. 194, 197-98, 72 L.Ed. 303 (1928) (holding that the Act of 1918, which was the predecessor to § 1498 and in which the government first assumed liability for the infringement of its contractors, was "intended to secure to the owner of the patent the exact equivalent of what it was taking away from him"). If we accepted the government's view of the matter, Rockwell would be insulated from liability—based on the contract requiring it to construct the spacecraft in a way that infringed the Williams patent—but the government also would be insulated from liability because it would not yet have "authorized" construction of such a spacecraft for purposes of § 1498. *See* Tr. 20,819-20 (arguing that the concept of authorization and consent involves "two prongs": the determination of the proper forum and the determination whether the government has agreed to accept liability); Tr. 20,830 (noting that there may be "a hiatus between the time that . . . a private party ceased to be liable and the time when the government would become liable").

number of other GPS spacecraft (including GPS 15, 18, 20, 21 and 23) that were manufactured pursuant to the same contract had in fact been the subject of a final DD 250 and had been launched. Surely whatever justification there is for requiring government acceptance before imposing liability, it is satisfied once the government accepts the first of a series of the accused spacecraft, which is identical in all relevant aspects to the remaining accused spacecraft.

Second, the fact that each of the accused spacecraft had been completely assembled, had been subjected to an inspection by the government, and had become government-furnished property[31] by the time the patent expired suggests that the government had accepted the patented devices. The significance of the final DD 250 was that it indicated that Rockwell had satisfactorily performed the testing component of its contract with the government for that particular spacecraft.[32] We believe that the acceptance of the

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[31] The contract provided that the space vehicles become government-furnished property upon "completion of inspection and acceptance" of the RCS installation line item. At that point, the vehicles were deemed to be delivered in place by the government to the contractor for testing (PX 3018.8).

[32] It is also true, as the government argues, that until the final DD Form 250 was executed, many of the risks associated with the contract remained on the contractor. Despite that assertion, we do not view the meaning of the term "accept," as used in the authorization and consent clause, to include acceptance of a contractor's performance of all contract line items in the contract. That clause prevents the government from incurring liability in situations where its contractor uses a device or method without the knowledge of the government that is later alleged to infringe a patent. *See Carrier Corp.*, 208 Ct.Cl. at 683, 534 F.2d at 248. The meaning of the term "acceptance" that we apply is consistent with that purpose and

spacecraft as government-furnished property is sufficient to constitute acceptance of the design of the spacecraft for purposes of § 1498.

Accordingly, we conclude that Rockwell manufactured each of the 14 accused GPS spacecraft for the government pursuant to the government's authorization or consent. See Appendix to Opinion for a list of the precise taking dates for the GPS spacecraft in issue.

In accordance with one of the stated objectives of the United States space program—to cooperate "with other nations and groups of nations," 42 U.S.C. § 2451(d)(7)—the United States has undertaken joint projects with other nations that have enabled the sharing of the costs and benefits. This portion of the opinion addresses defendant's liability for five spacecraft associated with four international programs. Those spacecraft are: Helios A and B, ISEE B, AMPTE UKS and Ariel 5.[33] We have determined elsewhere or the parties have stipulated that each of the spacecraft in issue in this part contain an embodiment of the Williams patent. *See* Appendix to

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more fairly responds to one of the purposes of § 1498—"to relieve private Government contractors from expensive litigation with patentees, possible injunctions, payment of royalties, and punitive damages," *TVI*, 806 F.2d at 1060.

[33] Originally, Hughes alleged that there was unlawful use by or for the government of two additional "foreign" spacecraft—GEOS 1 and 2. Both of those spacecraft were launched by the United States government in connection with an agreement between the United States and the European Space Agency. On August 4, 1993, the parties filed a joint stipulation withdrawing the GEOS spacecraft from the compensation base with prejudice. By order dated August 6, 1993, the stipulation was approved.

Opinion (listing citations to the bench rulings that pertain to these spacecraft). Although it is undisputed that the government had some association with each of these spacecraft, defendant contends that its participation did not constitute use or manufacture by or for the government within the meaning of 28 U.S.C. § 1498(a). Each of the spacecraft in issue was manufactured in another country and funded by another nation. Accordingly, we conclude that none of the spacecraft was *manufactured* "by or for the United States" within the meaning of § 1498(a). See Part V.A.3. for a discussion of the extraterritorial application of § 1498. Based on a consideration of the government's participation in the various spacecraft programs, we conclude that Helios A and B and ISEE B were used by the government within the meaning of § 1498(a) and that ARIEL 5 was not used by the government within the meaning of § 1498(a). With respect to AMPTE UKS, we find use by the government within the meaning of § 1498(a) but conclude that the temporary presence doctrine, as contained in 35 U.S.C. § 272, proscribes imposition of liability.

A

Section 1498(a) of title 28, United States Code, imposes liability on the government "[w]henever an invention described in and covered by a patent of the United States is used . . . by or for the United States without license. . . ." The language of the statute itself imposes two requirements—there must be a use and the use must be by or for the United States—and for reasons discussed below we infer a third requirement—that the use be within the United States. The first three sections of this subpart discuss these requirements in turn. The final section of

this subpart discusses the temporary presence doctrine, as codified in 35 U.S.C. § 272, which precludes liability for patent infringement if a vessel, aircraft or vehicle of another country carrying an infringing device enters the United States "temporarily" or "accidentally."

1. Use

As stated above in Part IV, the words "manufacture" and "use" (as well as the words "make," "use" and "sell" in title 35) were not defined by Congress but do have an established judicial interpretation; that interpretation is a broad one.[34]

In the first major case to interpret this language, *Bauer & Cie v. O'Donnell*, 229 U.S. 1, 10-11, 33 S.Ct. 616, 617, 57 L.Ed. 1041 (1913), the Supreme Court declared that the term "use," as used in a predecessor to title 35, was "comprehensive" and included "put [ting] into service any given invention."[35] *See* Webster's II New Riverside University Dictionary 1271 (1984) (defining "use" as "[t]o bring or put into service or action"). Although few subsequent cases have addressed the meaning of the term "use," those that have consistently followed the Supreme Court's lead in giving the term a broad interpretation. In

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[34] Because we consider the word "use" to have the same meaning in § 1498(a) and in title 35, we rely without distinction on cases arising under both statutory schemes.

[35] In an earlier decision, *Beedle v. Bennett*, 122 U.S. 71, 7 S.Ct. 1090, 30 L.Ed. 1074 (1887), the Supreme Court applied the term in the context of a patent on the process for driving a well. In that case, the Court concluded that a "continuing infringement" had occurred because "every time water [wa]s drawn from [the well] the patented process [wa]s necessarily used." *Beedle*, 122 U.S. at 78.

Olsson v. United States, 25 F.Supp. 495 (Ct.Cl.1938), *cert. denied*, 307 U.S. 621, 59 S.Ct. 792, 83 L.Ed. 1500 (1939), the Court of Claims concluded that the United States "used" howitzers (a type of cannon) that contained an embodiment of a patented invention even though the howitzers were never actually fired and had been disassembled for storage:

> Although held in storage in a convenient form for proper preservation the guns were, after being brought to this country, employed for the accomplishment of a purpose, i.e., the purpose of national defense. In these circumstances we think it is clear that there has been a "use" in the United States of plaintiff's invention for which he is entitled to recover compensation.

Olsson, 25 F.Supp. at 498. The Court of Claims revisited the issue of "use" liability in *Decca Limited v. United States*, 210 Ct.Cl. 546, 544 F.2d 1070 (1976), *cert. denied*, 454 U.S. 819, 102 S.Ct. 99, 70 L.Ed.2d 89 (1981). In that case, the accused device was a "system for broadcasting radio waves of a particular kind to be received on ships or aircraft by receivers able to receive and use them, to pinpoint the location of ships and planes on or over the sea." *Id.*, 210 Ct.Cl. at 552, 544 F.2d at 1074. In deciding that the system was "used," the court held that "a cause of action under § 1498 arises when the accused equipment is first *available* for use." *Id.* at 567, 544 F.2d at 1082 (emphasis added).

We glean from those precedents that the question of what constitutes "use" is a mixed question of fact and law to be determined on a case-by-case basis. A device may be "used" in many different ways, and all

uses that rely on the teachings of a patent constitute infringement.

The broad interpretation reflected in those general principles already has been applied in this case. In *Hughes Aircraft Co. v. United States*, 215 U.S.P.Q. 787 (Ct.Cl. Trial Div.1982), the court addressed the meaning of the term "use" with respect to spacecraft that were launched before the patent was issued, and thus were already in space when the patent term began. The government argued that it did not "use" spacecraft that had not actually activated the Williams attitude control system during the patent term; in those spacecraft, the Williams attitude control system was intended to be merely a back-up system. In rejecting that non-use argument, the court determined that actual firing of the precession thrusters was not necessary to constitute "use" of the invention because "there is no requirement in any of the claims that a control signal synchronized with the ISA be provided." *Hughes*, 215 U.S.P.Q. at 815. Instead, the court found that "[o]nly the capability to receive such a signal is claimed." *Id.* Hence, the court's holding regarding "use" of the Williams patent did not require an activation of the attitude control system.

Another decision in this case that has some bearing on the "use" issue is *Hughes Aircraft Co. v. United States*, 226 Ct.Cl. 1, 8-9, 640 F.2d 1193, 1194-97 (1980). In that case, the Court of Claims held that the Williams patent did not cover the ground control device. In doing so, the court, relying on clause (a) (claiming a "body adapted to spin about an axis"), held that the patent covered a spacecraft with certain specified features. Id. at 8-9, 640 F.2d at 1197 ("The invention was the satellite."). In our view, that case

establishes the rule that because the patent covers the spacecraft as a whole (i.e., a body adapted to spin about an axis) rather than simply the features of the attitude control system, the "use" question must focus on whether the spacecraft as a whole has been used.

For purposes of this case, it is important to consider whether launching a spacecraft constitutes a use of the patent. As the foregoing discussion suggests, we think it clearly does. *Hughes Aircraft*, 215 U.S.P.Q. 787, makes clear that the availability of the attitude control system on the spacecraft at a time when the spacecraft is being operated constitutes a use of the patent.

The government argues that because the attitude control system cannot be activated until the spacecraft separates from the launch vehicle in space, the launch cannot constitute a use of the patented invention. We think that argument is foreclosed by the decision of the Court of Claims in *Olsson*, which held that howitzers, in a disassembled state for purposes of storage, were used for purposes of § 1498(a) and by the fact that it is the spacecraft as a whole whose use constitutes a use of the patent.

2. "By or for the United States"

Next, we address the meaning of the phrase "by or for the United States." Although in most contexts the meaning of that phrase is relatively clear, the issue is complicated in this case by the association of the accused devices with cooperative arrangements between the United States and other governments. Again, as with the use question, much of the law on this point is found in earlier cases involving the Williams patent, in particular *Hughes Aircraft Co. v.*

United States, 209 Ct.Cl. 446, 534 F.2d 889 (1976) (a decision issued in the case at bar, No. 426-73), and *Hughes Aircraft Co. v. Messerschmitt-Boelkow-Blohm, GmbH*, 625 F.2d 580 (5th Cir.1980), *cert. denied*, 449 U.S. 1082, 101 S.Ct. 868, 66 L.Ed.2d 807 (1981). Both of those cases addressed the issue of whether United States involvement in international spacecraft programs constituted use by the government. Although both decisions purported to turn on the jurisdictions of the respective courts to entertain the action, both decisions directly addressed the meaning of the phrase "by or for the United States" in the context of specific international spacecraft programs. Accordingly, we consider those cases in some detail.[36]

Hughes Aircraft Co. v. United States, 209 Ct.Cl. 446, 534 F.2d 889 (1976), involved Skynet II, the pro-

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[36] We follow the interpretation those cases gave to the "by or for" language, particularly that of the Court of Claims (whose merits decisions are binding on this court), because to interpret the phrase "by or for the United States" differently for purposes of jurisdiction and liability, as the government suggests, would defeat the goal of providing a remedy for all patent infringements. That is so because the government's argument would result in certain "uses" being "by or for" the government for purposes of barring relief under title 35 in a suit against the contractor, and yet not sufficiently "by or for" the government to allow the patentee to maintain an action under § 1498 against the government itself.

Further, although both courts characterized their rulings as "jurisdictional," each actually resolved "use" issues on the merits. *See Sprull v. Merit Systems Protection Board*, 978 F.2d 679, 687 (Fed.Cir.1992) (describing the confusion that arises "when the factual allegations that constitute the cause of action include allegations which are necessary to establish jurisdiction").

duct of a joint program between the United States and the United Kingdom. A long-term cooperative aim of the two governments was to introduce spacecraft with interoperable characteristics so that each country "could effectively augment its own defense communications capacity by direct and reciprocal utilization of the other country's capacity." *Id.* at 460, 534 F.2d at 898. Skynet II was intended to be the United Kingdom segment of a joint defense satellite communications system.

In 1970, the United States and the United Kingdom outlined the respective responsibilities of each country in a "Memorandum of Understanding" (MOU). The MOU provided that the United Kingdom was responsible for the design, development and procurement of the spacecraft. In addition, following the spacecraft's positioning in final orbit, the United Kingdom was to have exclusive communications and operational control over Skynet II. The United States was responsible for providing technical assistance in the design of the spacecraft, procuring the launch vehicles and launching the spacecraft. In addition, in the event of an emergency, the United States could assume operational control of the spacecraft. Each government was to provide the communications and earth control stations required for its own use. Costs incurred by the United States on behalf of the United Kingdom were to be reimbursed by the United Kingdom.

The Court of Claims determined that Skynet II had been *manufactured for* the United States and that it had been used by the United States. In addressing whether Skynet II was manufactured for the United States, the court focused on the cooperative nature of

the program.[37] Quoting a statement by the Department of the Air Force, the court noted that

> *US involvement in the Skynet II program cannot be viewed as a mere sale of satellite launch services by an uninterested party.* Rather, the furnishing of the launch equipment and services was directly related to US National Security as an integral step toward expanding the US defense satellite communications system via the shared use cooperative program set forth in the aforementioned MOU's.

Id. at 460, 534 F.2d at 898 (emphasis added). The court then addressed the second ground—use by the United States. The court concluded that the United States "used" the spacecraft because the government assumed exclusive control of the project for some time. *Id.* at 466-67, 534 F.2d at 902. Specifically, after delivery of the fabricated spacecraft to the United States, the government, acting through NASA and the Air Force, assumed full and exclusive control of the project, which included testing of the spacecraft's components, testing and mating of the launch motors and vehicles, and direct tracking and commanding of the spacecraft to position it in its final orbit. *Id.*

Hughes Aircraft Co. v. Messerschmitt-Boelkow-Blohm, GmbH, 625 F.2d 580 (5th Cir.1980), *cert. denied*, 449 U.S. 1082, 101 S.Ct. 868, 66 L.Ed.2d 807 (1981), involved the Helios program, which is also at issue in this case. The Helios program was a joint

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[37] Because Skynet II was manufactured in England, we believe the "manufacture" prong of § 1498 did not actually have relevance. See Part V.A.3., *infra*. The issue of the extraterritorial application of § 1498(a), however, was neither raised nor addressed in that case.

research project between the Federal Republic of Germany and the United States. A 1969 MOU provided that Germany would design and test the spacecraft, integrate all of the experiments and control the spacecraft after launch, and that NASA would provide the launch vehicle, launch the spacecraft and provide tracking and data acquisition services. In deciding that the spacecraft were used by the United States, the Fifth Circuit emphasized that "the project was a shared project for the mutual benefit of both countries, with interrelated responsibilities for each." *Id.* at 584. The Fifth Circuit found significance in the facts that the United States contributed approximately $80 million of the total $260 million cost of the project, that three of the ten experiments on-board were sponsored by the United States, that NASA provided the launch rocket and launched the vehicle and that NASA provided tracking and data acquisition support during early phases of the mission. *Id.* at 581-84. Based on a totality of the circumstances, the court concluded that the project was a joint effort.

Unlike the Skynet project, NASA's only role following launch of the Helios spacecraft was to provide tracking and data acquisition services. German stations had exclusive control of the spacecraft after the launch. Hence, although the court did not identify a particular activity that constituted a "use," and instead took a totality of the factors approach, the decision itself is consistent with our view that launching a spacecraft constitutes a "use" of that spacecraft.[38]

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[38] The Fifth Circuit viewed the relationship between Germany and the United States as constituting a type of joint

Those cases stand for the principle that United States involvement in a joint international space program will be sufficient to make any use of the spacecraft a use "by" or "for" the government within the meaning of § 1498 if the project is a cooperative one with the potential of substantial benefits to the United States. Our view of those decisions is buttressed considerably by Congress' enactment in 1981 of 42 U.S.C. § 2457(1). That provision states in pertinent part:

> The use or manufacture of any patented invention incorporated in a space vehicle launched by the United States Government for a person other than the United States shall not be considered to be a use or manufacture by or for the United States within the meaning of section 1498(a) of title 28, unless [NASA] gives an express authorization or consent for such use or manufacture.

The Senate Report associated with this provision explains its purpose as follows:

> The launch capability of NASA is available to persons other than agencies of the United States on either a reimbursable or cooperative basis. Generally, a launch performed under a cooperative arrangement entails mutual benefits to the United States and the other person, such as the sharing of scientific data from the space vehicle. The courts have held that where a launch is part of such a cooperative arrangement that the use of any patented inventions incorporated in the space vehicle furnished by such other person is a use by

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venture so that any "use" by either country would be sufficient to impose liability on the United States.

> or for the Government within the meaning of 28 U.S.C. 1498(a). On the other hand, there are many instances where NASA provides launch services to another person on a reimbursable basis without any tangible benefits flowing to the Government other than monetary reimbursement for such launch services. In such cases, the Government should not be held liable under 28 U.S.C. 1498(a) since any use of a patented invention contained in the space vehicle for which launch services are provided is generally for the sole benefit of the person procuring the launch services.

S. Rep. No. 97-100, 97th Cong., 1st Sess. 52 (1981); *see* H.R. Rep. No. 32, 97th Cong., 1st Sess. 222 (1981). The legislative history strongly suggests that Congress understood the preexisting case law, just as we have explained it above, to impose liability for cooperative ventures, and enacted the statute to ensure that the government would not be liable when it acted merely to accommodate other nations. Hence, although the statute does not apply to all the "foreign" spacecraft at issue in this case,[39] we view it as supporting our interpretation of the "by or for" requirement in § 1498.

3. Application of § 1498 to Activities in Outer Space

It is generally recognized that the activities of nations in outer space are governed by public international law. Glenn H. Reynolds and Robert P. Merges, *Outer Space: Problems of Law and Policy* 25-47 (1989) (discussing international space law). The

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[39] Because the statute was enacted in 1981, it is only directly applicable to the AMPTE spacecraft, which were launched after 1981.

United States is a signatory to several treaties governing the exploration of outer space. The Treaty on Principles Governing the Activities of States in the Exploration and Use of Space, Including the Moon and Other Celestial Bodies (Outer Space Treaty), 18 U.S.T. 2410, T.I.A.S. No. 6347, 610 U.N.T.S. 205, was the first treaty to be adopted, and provides the basic framework for international space law. Article III of that treaty establishes that all activities in outer space must be conducted "in accordance with international law, including the Charter of the United Nations, in the interest of maintaining international peace and security and promoting international co-operation and understanding." Article II generally prohibits any nation from claiming sovereignty over areas of outer space, but Article VIII provides an exception, under which a State "on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof, while in outer space or on a celestial body."[40] The record indicates that ARIEL 5 and AMPTE UKS were registered as United Kingdom spacecraft, but the record does not indicate the state of registry of the other spacecraft in issue. The government argues that under the international law governing outer space, as established by the Outer Space Treaty, we may not apply § 1498 to claims arising in outer space relating to non-United States

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[40] The provision is implemented by another treaty—Registration of Objects Launched into Outer Space, 28 U.S.T. 695, T.I.A.S. No. 840 (Registration Convention). Under Article II of the Convention, the "launching State shall register the space object," and "[w]here there are two or more launching States in respect of any such space object, they shall jointly determine which one of them shall register the object."

registered spacecraft. We need not decide whether international law prohibits the extension of our patent laws to activities in outer space on foreign spacecraft because we conclude that Congress has not extended § 1498 to cover those activities.[41]

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[41] In 1990, Congress amended title 35 "to extend the protection of U.S. patent law to applicable activities conducted in outer space." S.Rep. No. 266, 101st Cong., 2d. Sess. (1990), reprinted in 36 U.S.C.C.A.N. 4058, 4062. The Inventions in Outer Space Act, P.L. No. 101-580, 104 Stat. 2863 (codified at 35 U.S.C. § 105), provides in part:

> Any invention made, used or sold in outer space on a space object or component thereof under the jurisdiction or control of the United States shall be considered to be made, used or sold within the United States for the purposes of this title, except with respect to any space object or component thereof that is specifically identified and otherwise provided for by an international agreement to which the United States is a party, or with respect to any space object or component thereof that is carried on the registry of a foreign state in accordance with the Convention on Registration of Objects Launched into Outer Space.

The Act does not apply to "any process, machine, article of manufacture, or composition of matter, an embodiment of which was launched prior to the date of enactment of this Act." 104 Stat. 2864. Accordingly, it has no direct effect on our case.

The legislative history indicates that the purpose of the law was "to clarify U.S. patent law with respect to its extraterritorial application aboard U.S.-flag spacecraft, in order to encourage private investment in research and manufacture conducted in outer space." 36 U.S.C.C.A.N. at 4058. According to that report, "the current state of the patent law is ambiguous with respect to jurisdiction over activities in outer space." *Id.* at 4059. Moreover, the legislative history suggests that the Act was consistent with international law. *Id.* at 4061-62.

The Supreme Court has set forth a "presumption that Acts of Congress do not ordinarily apply outside our borders."[42] *Sale v. Haitian Centers Council, Inc.*, — U.S. ——, ——, 113 S.Ct. 2549, 2560, 125 L.Ed.2d 128 (1993) (applying presumption to prevent application of § 243(h)(1) of the Immigration and Nationality Act to actions in the high seas); *see Smith v. United States*, — U.S. ——, ——, 113 S.Ct. 1178, 1183, 122 L.Ed.2d 548 (1993) (holding that the presumption prevented application of the Federal Tort Claims Act to a claim arising in Antarctica). Hence, those cases suggest that, absent some textual indication to the contrary, we should construe § 1498 not to apply to claims arising beyond United States territorial limits.

The only portion of § 1498 that directly addresses extraterritorial application states that the provision "shall not apply to any claim arising in a foreign country." 28 U.S.C. § 1498(c); *see Decca Limited v. United States*, 210 Ct.Cl. 546, 550, 544 F.2d 1070, 1072 (1976) (stating that § 1498 does not apply to "acts in foreign countries that would be infringements at home"), *cert. denied* 454 U.S. 819, 102 S.Ct. 99, 70

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[42] Although Hughes points out that application of our laws to activities in outer space would not be likely to interfere with the laws of other nations, the Supreme Court has made clear "that the presumption has a foundation broader than the desire to avoid conflict with the laws of other nations." *Sale v. Haitian Centers Council, Inc.*, — U.S. ——, ——, 113 S.Ct. 2549, 2560, 125 L.Ed.2d 128 (1993). Instead, "the presumption is rooted in a number of considerations, not the least of which is the common- sense notion that Congress generally legislates with domestic concerns in mind." *Smith v. United States*, — U.S. ——, —— n. 5, 113 S.Ct. 1178, 1183 n. 5, 122 L.Ed.2d 548 (1993).

L.Ed.2d 89 (1981). That provision, by itself, does not prevent the application of § 1498 to activities in outer space, because outer space is not a "foreign country" in the ordinary meaning of that phrase.

The analogous provisions of title 35, however, strongly support a reading of § 1498 limited to activities in this country. First, section 154 of title 35, United States Code, provides that a patent grants "the right to exclude others from making, using, or selling the invention throughout the United States." Section 100(c) of that title provides that "[t]he terms 'United States' and 'this country' mean the United States of America, its territories and possessions." Hence, because the patent itself grants rights only against use in the United States, it would be quite odd to interpret § 1498 as imposing liability on the government for use outside this country. *See* also 35 U.S.C. § 271(a) (defining an infringer as "whoever without authority makes, uses or sells any patented invention, *within the United States* during the term of the patent" (emphasis added)). The Supreme Court's holding in *Deepsouth* that our patent laws have no extraterritorial effect, 406 U.S. at 531, 92 S.Ct. at 1708,[43] bolsters our view that § 1498 in its entirety should be construed consistently with title 35 as limited in application to United States territory and thus as not applying in outer space (absent a specific enactment extending the reach of patent laws to uses in space).

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[43] As we noted in Part IV.C.1., supra, the result in Deepsouth was superseded by Congress. Nonetheless, as our previous discussion indicates, Congress did not define any of the statutory terms in issue but merely provided for an additional type of infringement.

Finally, and perhaps most dispositively, the Supreme Court's recent interpretation of a similar phrase constrains us to limit § 1498 to activities in this country. *Smith v. United States* involved the Federal Tort Claims Act (FTCA), which contains language similar to that in § 1498(c) providing that the statute did not apply in a foreign country.[44] The Court held that the FTCA did not apply to claims arising in Antarctica. Although the decision rested in part on the Court's view that the phrase "foreign country" meant a region of land outside the borders of the United States, without regard to whether it is a sovereignless region or a sovereign state, *id.*, — U.S. at ——, 113 S.Ct. at 1181, the Court went further, holding that "[t]he applicability of the presumption is not defeated here just because the FTCA specifically addresses the issue of extraterritorial application in the foreign-country exception," *id.* — U.S. at ——, 113 S.Ct. at 1183. Instead, the Court held that the presumption should apply unless there was affirmative evidence of congressional intent to apply the FTCA to claims arising in Antarctica.

In our view, *Smith* also prevents the assertion of s 1498(a) over claims arising in outer space. *See Smith v. United States*, — U.S. at ——, 113 S.Ct. at 1184, 122 L.Ed.2d 548 (1993) (Stevens, J., dissenting) (noting that the case "will surely have its parallels in outer space"). Accordingly, we conclude that § 1498(a) does not apply to activities in outer space and thus we

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[44] *Compare* 28 U.S.C. § 1498(c) ("The provisions of this section shall not apply to any claim arising in a foreign country."), with 28 U.S.C. § 2680 (" The provisions of [the Act] shall not apply to— . . . (k) Any claim arising in a foreign country.").

confine our analysis to activities occurring within the territorial limits of the United States.

4. Temporary Presence Doctrine

The temporary presence doctrine presupposes that there has been some use of an invention within the United States that would otherwise constitute infringement of a United States patent. The government contends that there has been no such use within the United States with respect to any of the spacecraft in issue. Nonetheless, as an alternative defense, the government argues that liability for any such use would be excluded by the temporary presence doctrine. Because we view the launch of a spacecraft containing an embodiment of the patented invention from the United States as a "use" of that invention within the United States, we briefly address the effect that this doctrine has on our analysis.

The temporary presence doctrine was enunciated by the Supreme Court in *Brown v. Duchesne*, 60 U.S. (19 How.) 183, 15 L.Ed. 595 (1856), and, on an international scale, was the subject of a convention to which the United States is a party.[45] In 1952, Congress codified the doctrine at 35 U.S.C. § 272. *Brown v. Duchesne* involved an action brought by the owner of a United States patent on a gaff for a sailing vessel, against a French national who sailed a French schooner that allegedly contained the infringing gaff

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[45] Paris Convention for the Protection of Industrial Property of 1883, as revised July 14, 1967, 21 U.S.T. 1583, T.I.A.S. No. 6927, 828 U.N.T.S. 305.

from St. Peters, to Boston, and back to St. Peters. The Court phrased the issue as

> [W]hether any improvement in the construction or equipment of a foreign vessel, for which a patent has been obtained in the United States, can be used by such vessel within the jurisdiction of the United States, while she is temporarily there for the purposes of commerce, without the consent of the patentee?

Brown, 60 U.S. at 194. Relying heavily on its views that the amount of "use" that occurred in the United States was minimal and that an extension of the patent laws to cover such a use would seriously undermine Congress' treaty- making power and interfere with its power to regulate international commerce, *id.* at 196-97, the Court held that the patent laws did not permit such an interpretation, *id.* at 198.

Section 272 of title 35, United States Code, provides:

> The use of any invention in any vessel, aircraft or vehicle of any country which affords similar privileges to vessels, aircraft or vehicles of the United States, entering the United States temporarily or accidentally, shall not constitute infringement of any patent, if the invention is used exclusively for the needs of the vessel, aircraft or vehicle and is not sold in or used for the manufacture of anything to be sold in or exported from the United States.

Hughes contends that launches occurring before 1981, when Congress added 42 U.S.C. § 2457(k) (providing that "[a]ny object intended for launch, launched, or assembled in outer space shall be con-

sidered a vehicle for the purpose of section 272"), are not subject to the doctrine because spacecraft, at that time, were not vessels, aircraft or vehicles.[46] We agree with plaintiff's position. We emphasize that in the absence of said 1981 enactment (in effect declaring a spacecraft brought here for launch into outer space to be a "vehicle" within the meaning of the temporary presence doctrine) such spacecraft would properly be deemed cargo brought to this country for use (i.e., launch), *not a vehicle or vessel* within the contemplation of the temporary presence doctrine. Among the five foreign spacecraft addressed in this opinion, only AMPTE UKS could be affected by the 1981 amendment; the other four were launched prior to 1981.

The only published decision discussing 35 U.S.C. § 272 of which we are aware, *Cali v. Japan Airlines, Inc.*, 380 F.Supp. 1120 (E.D.N.Y.1974), *aff'd without op.*, 535 F.2d 1240 (2nd Cir.1975), involved foreign transoceanic passenger and freight air carriers that contained a modification to a jet engine that was covered by a United States patent. The plaintiff contended that the regular and extensive presence of the carriers in the United States could not be considered "temporary" within the meaning of the temporary presence doctrine. In concluding that the word "temporary," as used in § 272, could not be construed so narrowly, the court stated that the word "could not sensibly mean any less than entering for the purpose

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[46] In support of that interpretation, see 1 U.S.C. §§ 3, 4 (defining "vessel" as "every description of watercraft or other artificial contrivance used, or capable of being used, as a means of transportation on water" and "vehicle" as "every description of carriage or other artificial contrivance used, or capable of being used, as a means of transportation on land").

of completing a voyage, turning about, and continuing or commencing a new voyage." *Cali*, 380 F.Supp. at 1126. The court compared

> a[n] [aircraft], manufactured in France and powered with such an engine, delivered here for use by an airline in this country for domestic traffic, even though manufactured and sold in France, and a foreign aircraft arriving here on an international flight only to unload, turn about, reload and depart.

Id.

Our case is substantially different from *Cali* and *Brown v. Duchesne*. In those cases, the entries of the vessels and aircraft (operating as means of conveyance) were for purposes of depositing cargo and passengers and initiating new trips elsewhere. When a spacecraft is delivered to the United States for the purpose of allowing the United States to launch it, the spacecraft is the *cargo* brought here for an essential *use*, not a "vessel" or "vehicle" which enters the United States as a means of conveyance. Thus, we conclude that § 272 has no application to spacecraft launched before 1981.[47]

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Having discussed the legal requirements for liability under s 1498, we proceed to address the specific international programs associated with the foreign spacecraft in issue. At the outset, we note that the parties generally agree about the extent of the government's involvement in the various programs.

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[47] For a discussion of the application of § 272 to launches occurring after 1981, see Part V.B.3. which addresses AMPTE UKS.

Our conclusions about the extent of United States involvement are primarily based on memoranda of understanding (MOUs) executed by the United States and the various foreign governments involved in the respective programs.

1. Helios

The Helios[48] program (named for the Greek god of the sun) was a joint project between the Federal Republic of Germany and the United States. Hughes alleges that the government is liable for use of two Helios spacecraft, Helios A and B. In April 1969, following an extensive cooperative effort, a joint United States/German Mission Definition Group issued a report discussing the feasibility of a joint program. The report defined three objectives: (1) to provide German and United States experimenters an opportunity to conduct integrated experiments aimed at investigating properties and processes in interplanetary space near the sun, (2) to "advance the technical and technological expertise of German industry" and (3) to allow Germany to develop "more effective and more sophisticated management experience" (DX 2514B at 1-2). Further, the report contained design recommendations for numerous aspects of the spacecraft, including a detailed discussion of attitude control.

On June 10, 1969, shortly after the mission definition report declared the project feasible, NASA and the German Ministry for Scientific Research exe-

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[48] Helios was also the subject of the decision in *Hughes Aircraft Co. v. Messerschmitt-Boelkow-Blohm, GmbH*, 625 F.2d 580 (5th Cir.1980), *cert. denied*, 449 U.S. 1082, 101 S.Ct. 868, 66 L.Ed.2d 807 (1981), discussed extensively in Part V.A.2. of this opinion.

cuted an MOU outlining the details of the Helios program. According to the MOU, the "primary objective of Project HELIOS [was] to investigate the properties of and processes in interplanetary space in the direction of and close to the sun by developing, launching, and operating automated spacecraft" (PX 1033C at 1). The MOU required NASA to provide its experiments and the portions of the spacecraft and instruments peculiar to those experiments, to provide a launch vehicle and launch the spacecraft, to provide tracking and data acquisition services during certain phases of the mission, to reduce, analyze and distribute certain data and to provide training and consultation to the Germans as needed.[49] On the other hand,

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[49] The relevant portion of the MOU required NASA to use its best efforts to:

> A. Provide instrumentation for U.S.-sponsored experiments that are agreed elements of the payload.
>
> B. Supply those parts of the spacecraft and ground checkout equipment peculiar to the U.S.-sponsored experiments.
>
> C. Provide a launch vehicle of the Atlas/Centaur/TE 364-4 class, payload adapter section (including separation system), spin table, and shroud for each mission.
>
> D. Launch the spacecraft.
>
> E. During Phases I and II provide tracking and data acquisition support using available U.S. near earth, deep space, and space flight operations facilities.
>
> F. During Phase III provide for the use of elements of the Deep Space Network (DSN) which are mutually agreed to be necessary.
>
> G. Reduce, analyze and distribute data in accordance with a mutually agreed plan.
>
> H. Make available such training of German personnel in . . . [German] areas of responsibility for direct utilization

the MOU required the German agency to provide its experiments and related instrumentation, to provide both of the spacecraft, to integrate all of the experiments with the spacecraft, to deliver the spacecraft to the launch site, to supply tracking and data acquisition services during certain phases, to control the spacecraft during all phases, to reduce, analyze and distribute certain data and to cooperate with the training of German personnel.[50] Each party to the

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in this joint project as may be requested by . . . [the German agency] and as is feasible within the limitations of NASA operational requirements.

I. Provide relevant technical consultation and technical data as mutually agreed.

J. Provide technical assistance in testing the spacecraft and review final acceptance tests of the spacecraft. (PX 1033C at 3-4).

[50] That portion of the MOU required the German agency to use its best efforts to:

A. Provide instrumentation for those German experiments that are agreed elements of the payload.

B. Design, fabricate, and test all spacecraft. Integrate all experiments, including those from the United States, with the spacecraft and environmentally test the entire spacecraft system.

C. Deliver to the launch site a flight qualified spacecraft for each flight mission and flight qualified spares for all critical subsystems.

D. Supply payload and spacecraft ground checkout and spacecraft launch support equipment.

E. As mutually agreed, support each mission with tracking and data acquisition and control facilities available to the . . . [German agency].

F. Control the spacecraft during all phases.

G. Reduce, analyze and distribute data in accordance with a mutually agreed plan.

MOU was responsible for paying the costs incurred in discharging its responsibilities; neither was to be reimbursed by the other for any of its costs.

Messerschmitt-Boelkow-Blohm (MBB), a contractor hired by Germany, designed, constructed and tested Helios A and B in facilities near Munich (Tr. 11876-78).[51] The Helios spacecraft contained ten experiments, three of which were contributed by the United States (Ousley deposition at 9-10). NASA launched Helios A and B from Cape Canaveral, Florida on December 10, 1974 and January 15, 1976, respectively (Tr. 11888, 11891); the attitude control systems were first activated in space shortly after separation from the launch vehicles (Tr. 11950). Thereafter, NASA and the German agency cooperated in performing the mission substantially as planned, with German personnel assuming complete responsibility for controlling the spacecraft (Tr. 11952-55). NASA's main role following launch was to provide tracking and data acquisition services during some phases of the mission.

Tracking and data acquisition is accomplished by the use of a worldwide network of NASA ground stations. These facilities are interconnected by

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H. Make available German personnel for such training programs as may be agreed to.

I. Provide necessary communications required to link German operations facilities with a NASA communication terminal, the location of which will be mutually agreed between Project Managers.

(PX 1033C at 2-3).

[51] NASA had a purely advisory role in the design and specifications for the construction of the Helios spacecraft (Ousley deposition at 7-8).

ground communications lines, undersea cables and communications circuits. The interconnections provide the communications capability needed among the various facilities, spacecraft and the control centers in the United States from which the flights are directed. During the years in question, NASA used two types of facilities—the Spaceflight Tracking and Data Network (STDN), supporting orbital missions, and the Deep Space Network (DSN), supporting planetary and interplanetary missions. S.Rep. No. 100, 97th Cong., 1st Sess. 41-42 (1981). The types of support provided by those networks are as follows:

> (1) tracking to determine the position and trajectory of vehicles in space; (2) acquisition of scientific and Earth applications data from onboard experiments and sensors; (3) acquisition of engineering data on the performance of the spacecraft and launch vehicle systems; (4) transmission of commands from ground to spacecraft; (5) communication with astronauts and acquisition of biomedical data on their condition; (6) communication of information between the various ground facilities and central control centers; and (7) processing of data acquired from the launch vehicles and spacecraft.

Id. That function was described at trial as the provision of a "bent pipe."[52] Tr. 9098, 9739, 13813-14.

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[52] One of the government's expert witnesses, Jeremiah J. Madden, described that function as follows:

> What NASA has been trying to do for years and we are accomplishing it more and more every year is that we want the user of a spacecraft to not even know that we exist, like we are a clear piece of glass. He sits there and he wants to do something to his spacecraft. He picks up essentially

In 1974, Hughes filed an action against MBB in the United States District Court for the Middle District of Florida, alleging that MBB infringed the Williams patent. As a result of that litigation, the Administrator of NASA issued an authorization and consent letter dated March 18, 1977, which provided:

> The United States Government hereby gives its authorization and consent, without prejudice to any rights of indemnification, for all use and manufacture of any invention described in and covered by U.S. Patent Nos. 3,758,051 [the Williams patent] and Reissue 26,887 in the performance of the obligations of the Government of the Federal Republic of Germany under the Memorandum of Understanding (MOU) of June 10, 1969 and in the performance of the obligations of MBB under its contract with the Government of the Federal Republic of Germany for services to be performed in the United States relative to the Helios satellites. This authorization and consent shall apply retroactively to all Helios-connected activities that have taken place.

PX 1033C-1. As we discussed in Part V.A.2., the district court ultimately concluded that the allegedly infringing devices were used by the United States and that the infringement action therefore properly belonged in the Court of Claims; the Fifth Circuit affirmed. *Hughes Aircraft Co. v. Messerschmitt-*

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what you would call a telephone and talks directly to the spacecraft. And he does not know what channel we are going through, whether we are going through via satellite, or whether we are going through a ground link, or whether we are going out of Santiago, or out of Madrid or anywhere else. Tr. 13814.

Boelkow-Blohm, GmbH, 437 F.Supp. 75 (M.D.Fla. 1977), aff'd, 625 F.2d 580 (5th Cir.1980).

Based on these facts and the three requirements for liability under § 1498(a) discussed in Part V.A., we conclude that Helios A and B should be included in the compensation base. First, NASA's launch of both of the spacecraft constituted a use of the patented invention. Second, that use was "by or for" the government because the project was a cooperative one resulting in a considerable benefit to the United States government. A review of the MOU signed by the Federal Republic of Germany and the United States demonstrates that both parties considered their project a cooperative arrangement for mutual benefit. According to the MOU, the primary purpose of the mission was to study the properties of interplanetary space near the sun by sharing the costs and responsibilities associated with building, testing, launching and controlling the spacecraft.[53] Nothing about the execution of that plan suggests that the parties considered the project anything other than a cooperative one. Further, although we base our decision on use *by the government* rather than *use for the government*, we view the government's issuance of an authorization and consent letter[54] as

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[53] It is true that a subsidiary purpose of the project was to advance Germany's technical and management expertise. Nonetheless, we do not view that purpose as undermining the main objective, and, even if it had been the sole purpose, we do not suggest that it would be insufficient to demonstrate the intent of the United States to embark in a cooperative project.

[54] As discussed above, a finding that the government authorized or consented to a "use" is a prerequisite to a finding that use by a contractor of a patented invention was use "for" the government.

persuasive evidence of the joint nature of the Helios project. Third, the use was within the territorial borders of the United States because it was launched from Cape Canaveral, Florida. Hence, we conclude that the government used Helios A and B for its benefit within the United States and therefore is liable under § 1498(a).

2. ISEE

The International Sun-Earth Explorer Program (ISEE) was a joint project between the United States and the European Space Research Organization, now referred to as the European Space Agency.[55] (The current and predecessor organizations are referred to as "ESA.") This portion of the opinion addresses Hughes' entitlement to recovery for ISEE B.[56] On March 17, 1975, NASA and ESA executed an MOU outlining their respective roles in the project.

According to the MOU, the mission of the ISEE spacecraft program was to make a joint contribution to the International Magnetospheric Study (IMS) by focusing on solar-terrestrial relationships in the earth's magnetosphere[57] (PX 1102 at 1). The IMS was a "coordinated international cooperative program to study key problems of our nearby space environment" (PX 1037JJ-1). The ISEE spacecraft were "core" or

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[55] The ESA is a consortium of eleven European countries headquartered in France.

[56] The government conceded that ISEE A and C were manufactured or used by or for the government. See Appendix to Opinion.

[57] The magnetosphere is the region of space in which the earth's magnetic field dominates and controls the behavior of charged particles.

"reference" spacecraft for the IMS. The ISEE program involved three spacecraft, ISEE A, B and C (also known as "Mother," "Daughter" and "Heliocentric," respectively). Two of those spacecraft, ISEE A and B, equipped with similar experiments, were to travel at a controlled distance from each other making similar simultaneous measurements. The third spacecraft, ISEE C, was to act as a monitor for the solar wind.

The MOU required NASA to contribute ISEE A, to integrate ISEE A and B and to test the dual spacecraft, to provide a launch vehicle and deliver ISEE A to the launch site, to provide tracking and data acquisition services as agreed and to provide technical advice as needed.[58] On the other hand, the MOU

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[58] The relevant portion of the MOU required NASA to use its best efforts to:

> a. design, fabricate, integrate and test the ISEE-A spacecraft on the 1977 ISEE-A/ISEE-B mission;
>
> b. integrate the . . . ISEE-B spacecraft with the ISEE-A;
>
> c. test the completed dual spacecraft and transport ISEE-A and its necessary ground support equipment to the launch site;
>
> d. provide one Thor-Delta launch vehicle of suitable configuration with necessary ground support equipment and conduct the simultaneous launching of the ISEE-A/ISEE-B spacecraft;
>
> e. provide scientific instrumentation acceptable to [ESA] for integration into the ISEE-B spacecraft;
>
> f. provide tracking and data acquisition services for the ISEE-A and ISEE-B spacecraft as arranged with [ESA] and deliver processed data to the investigators;
>
> g. arrange the participation of individual scientists in the payloads for the ISEE-A spacecraft; this will include making direct arrangements with the appropriate na-

required ESA to contribute ISEE B, to deliver it for integration with ISEE A and then to the launch site, to provide tracking and data acquisition as agreed and to provide consultation as needed.[59] Each party was to

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tional authorities for the non-U.S. investigations on the spacecraft;

h. provide telemetry tapes for data acquisition at all NASA Spaceflight Tracking and Data Network (STDN) Stations, and provide copies of telemetry tapes to [ESA] as arranged with [ESA];

i. provide technical advice and consultation, as arranged with [ESA].

(PX 1102 at 2-3).

[59] The relevant portion of the MOU required ESA to use its best efforts to:

a. design, fabricate, test and integrate the ISEE-B spacecraft for the 1977 ISEE-A/ISEE-B mission; deliver the ISEE-B spacecraft to a designated site in the United States for integration with the ISEE-A spacecraft and supervise the ISEE-B spacecraft throughout the testing of the completed dual spacecraft and subsequent launch operations;

b. provide and transport to the designated launching site in the United States the ISEE-B spacecraft and necessary ground support equipment;

c. participate in tracking and data acquisition on the ISEE-A/ISEE-B mission as arranged with NASA;

d. arrange with appropriate national authorities for the participation of individual scientists in the payload of the ISEE-B spacecraft;

e. provide telemetry tapes for data acquisition at all [ESA] Tracking and Data Network Stations, and provide copies of telemetry tapes to NASA as arranged with NASA;

pay the costs associated with fulfilling its responsibilities under the MOU.

ISEE A and C were designed and constructed by NASA at Goddard Space Center (PX 1029K; PX 1029N).[60] ESA funded the construction of ISEE B (PX 1029K; Tr. 13793-96). ISEE A and B were launched on October 22, 1977 from Cape Canaveral, Florida (PX 1029K), and ISEE C was launched on August 12, 1978 from the same site (PX 1029N). Thereafter, the mission was executed in accordance with the division of responsibility outlined in the MOU, with NASA providing tracking services for all three spacecraft and controlling ISEE A and C and ESA controlling ISEE B (Tr. 13791). The MOU between the United States and ESA was modified by letter dated December 17, 1976, to include an authorization and consent clause because of the ESA's concern about the Williams patent litigation (PX 1103).

Based on these facts, we conclude that ISEE B should be included in the compensation base; the three requirements for finding liability under § 1498(a) are present. First, NASA's launch of ISEE B constituted a use of the patented invention. Second, that use was "by or for" the government because the ISEE pro-

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f. provide technical advice and consultation, as arranged with NASA.

(PX 1102 at 3).

[60] A STAR consortium of 10 countries supervised construction and designed the ISEE B. Those countries were Belgium, Denmark, France, Spain, Germany, Italy, the Netherlands, Sweden, Switzerland, and the United Kingdom (PX 1029K). The spacecraft was assembled at Dornier Systems (the prime contractor) in Germany (Tr. 13793-95).

gram was a cooperative one. The applicable MOU demonstrates that NASA and ESA considered the mission of the ISEE program to be making a joint contribution to the International Magnetospheric Study. That mission was executed as planned. Put simply, all of the evidence suggests that NASA launched ISEE B as its part of a joint program and not as a disinterested party. In fact, this program, even more so than Helios, involved a great deal of cooperation, with the United States being required to contribute a spacecraft that would travel at a controlled distance from ISEE B. In addition, the authorization and consent letter issued by NASA demonstrates that the government considered the ISEE program a joint project. Third, because the ISEE B was launched in Florida, the use occurred within the territorial borders of the United States. Thus, we conclude that Hughes is entitled to recovery with respect to ISEE B.

3. AMPTE

The Active Magnetospheric Particle Tracer Explorer (AMPTE) program involved two international agreements—one between the Federal Republic of Germany and the United States and one between the Federal Republic of Germany and the United Kingdom. The AMPTE program included three spacecraft: the Ion Release Module (IRM) contributed by Germany, the United Kingdom Subsatellite (UKS) contributed by the United Kingdom and the Charge Composition Explorer (CCE) contributed by the United States. This portion of the

opinion addresses Hughes' accusation of AMPTE UKS.[61]

On October 15, 1981, the United States and the Federal Republic of Germany executed an MOU that detailed their respective duties. That MOU described the mission as follows:

> The primary scientific objective of the mission is to study the entry of solar wind ions into the magnetosphere and the processes by which particles are energized in the magnetospheric tail. Tracer ions (lithium and barium) will be released and measured in the solar wind and within the distant magnetosphere. The AMPTE mission will also seek to obtain comprehensive measurements of the composition and dynamics of the natural charged particle populations within the Earth's magnetosphere. Furthermore, it is intended to study, by in-situ measurements and by remote optical observations, the interactions of released and ambient plasmas.
>
> In addition, the mission will serve to establish values of physical parameters necessary for planing and execution of active experiments on Shuttle/Spacelab missions.

PX 1027E at 2-3; see Tr. 2579-80, 9002-03. The MOU between the United States and Germany contem-

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[61] The government acknowledged that AMPTE CCE contained an embodiment of the Williams patent and was manufactured or used by or for the government. See Appendix to Opinion n. 2. Hughes acknowledged that AMPTE IRM did not infringe the Williams patent but contends that it should be included in the compensation base under the entire market value rule. We shall address the entire market value issue in a subsequent opinion on damages.

plated the use of two spacecraft—the CCE and IRM. That agreement required NASA to contribute the CCE spacecraft, to launch both spacecraft, to provide tracking for IRM as needed and for CCE and to process AMPTE CCE data.[42] Likewise, the MOU

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[42] The relevant portion of the agreement required NASA to use its best efforts to:

> (a) Design, fabricate, test, integrate and prepare for launching a complete CCE spacecraft, including its apogee kick stage.
>
> (b) Provide the CCE Medium Energy Particle Analyzer (MEPA).
>
> (c) Provide the CCE Hot Plasma Composition Experiment (HCPE).
>
> (d) Provide the collimator, time-of-flight section, and the high voltage power supplies for the CCE Charge Energy Mass Spectrometer (CHEM).
>
> (e) Provide specifications of the environmental conditions in the launch vehicle and the appropriate mechanical and electrical interfaces . . . for use in preparing the IRM for launch.
>
> (f) Launch the CCE and the IRM on the same Delta launch vehicle.
>
> (g) Conduct tracking and telemetry operations for the CCE as defined in the . . . AMPTE Project Plan (as defined in Article 5d) and the Support Instrumentation Requirements Document (SIRD).
>
> (h) Provide periodic tracking and telemetry support for the IRM as mutually agreed and defined in the . . . AMPTE Project Plan and SIRD.
>
> (i) Process CCE science data, and provide these data to the Investigators in a form suitable for scientific analysis.

required Germany to contribute the AMPTE IRM spacecraft, to deliver it to the launch site, to conduct tracking operations for AMPTE IRM as agreed with NASA and to process AMPTE IRM data.[63] The MOU

> (j) Arrange for procurement of the IRM perigee kick stage. The cost will be shared equally by NASA and [the German agency]. A Deposit Account at NASA will be used for this purpose.

(PX 1027E at 3-4).

[63] The relevant portion of the agreement required Germany to:

> (a) Design, fabricate, test, integrate and prepare for launching a complete IRM spacecraft, including the chemical release canisters and a magnetometer, and deliver it to the Kennedy Space Center.
>
> (b) Provide additional diagnostic instrumentation on the IRM, provided the agreed primary mission objectives and the presently scheduled launch date are not impacted.
>
> (c) Select, integrate and prepare for launching the IRM perigee kick stage.
>
> (d) Provide analog electronics and data processing unit (DPU) for the CHEM instrument and support the participation of the Max Planck Institute for Aeronomy (MPAE) in the CHEM operations analysis
>
> (e) Support the participation of the Max Planck Institute for Physics and the Astrophysics in the part development of electron sensors of the HCPE.
>
> (f) Support the participation of German personnel in Joint Working Group and review meetings, integration, launch, and operations activities and observation campaign in the U.S. and elsewhere.
>
> (g) Conduct tracking and telemetry operations for the IRM as defined in the NASA/BMFT AMPTE Project Plan.

also provided that NASA and the German space agency would each bear the costs of discharging their respective responsibilities.

The AMPTE CCE and IRM were originally planned to be launched in a stacked form, with the CCE on top of the IRM and with an interface adapter inserted between the two spacecraft. Then, Germany and the United Kingdom developed a novel design for a spacecraft which could be built on and around the interface adapter. Tr. 9003-04, 15079-80.

Subsequently, by separate agreement, the United Kingdom and the Federal Republic of Germany agreed to launch an additional spacecraft, AMPTE UKS, to be provided by the United Kingdom. The MOU stated that the spacecraft would be a subsystem of the AMPTE IRM and was intended to "improve the in-situ study of the interaction between the released [barium] and [lithium] plasmas with the natural environment" (PX 1027II). In that agreement, the United Kingdom agreed to provide the AMPTE UKS spacecraft, to control and provide tracking services for the spacecraft and to process data from the

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(h) Process and provide IRM orbital and science data to the Investigators in a form suitable for scientific analysis.

(i) Coordinate, in consultation with NASA, ground-based, airborne and other geophysical observations prior to and during the chemical releases.

(j) Support the procurement of the IRM perigee kick stage on a cost-shared basis as noted in Article 3, paragraph (j).

(PX 1027E at 3-4).

spacecraft;[64] in return, Germany agreed to provide various services related to integrating UKS with the IRM.[65] AMPTE UKS was built in the United

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[64] The relevant portion of the agreement required the United Kingdom to:

> (a) Design, fabricate, test, integrate and prepare for launching a complete UKS spacecraft. The spacecraft will include a magnetometer, plasma wave and particle detectors, and station-keeping propulsion system.
>
> (b) Provide the inter-spacecraft ranging unit to be flown on the IRM and support its integration and test.
>
> (c) Support the participation of UK personnel in Joint Working Group and review meetings, integration, launch and operations activities in Germany, the United States and elsewhere.
>
> (d) Conduct tracking, telemetry and orbit manoeuvre operations for the UKS.
>
> (e) Provide UKS orbital and science data to the Investigators in a form suitable for scientific analysis.
>
> (f) Make provision regarding UK activities for closely coordinated operations between the German and UK operations control centres.
>
> (g) Provide a data link between the UK Operations Control Centre (UK OCC) and the German Space Operations Centre (GSOC) and speedy production of the physical parameters selected for the summary data sets.

(PX 1027II).

[65] The relevant portion of the MOU required Germany to:

> (a) Provide a vhf antenna for, and integrate and test, the interspacecraft ranging unit on the IRM.
>
> (b) Provide support for joint IRM/UKS integration and test activities described in the . . . [IRM/CCE] AMPTE-Project Plan.
>
> (c) Support the participation of German personnel in the Joint Working Group and review meetings, integrations and operation in the UK and elsewhere.

Kingdom and funded by the Science Research Council (Tr. 15079). The spacecraft was registered with the United Nations as a United Kingdom spacecraft (Tr. 15081). The spacecraft contained five experiments, all contributed by the United Kingdom (Tr. 15077).

NASA launched the three AMPTE spacecraft on a Delta/Thor vehicle on August 16, 1984 (Tr. 9004). The three spacecraft were stacked with the IRM on the bottom, the UKS in the middle and the CCE on top. The spacecraft remained attached in the launch phase and separated in space, with the CCE in one orbit (within the earth's magnetosphere) and the UKS and IRM in a different orbit (outside of the earth's magnetosphere) (Tr. 2582-85, 9007-08). The UKS kept a position relative to the IRM so that it provided a second reference for studying the release of chemi-

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(d) Make provision for closely coordinated operations between the UK OCC and the GSOC in accordance with the . . . [IRM/CCE] AMPTE Project Plan.

(e) Provide specifications of the environmental conditions in the launch vehicle and the appropriate mechanical and electrical interfaces to SERC for use in preparing the UKS for launch.

(f) Provide the adaptor section to be used as the interface between the UKS and the CCE, and all interface cabling, connectors and separation hardware required by the CCE and IRM.

(g) Design, fabricate, test, integrate and prepare for launching an adaptor cone for use as the IRM/CCE structural interface in the event that the UKS is not available for launch.

(h) Make provision for speedy production of summary data sets comprising IRM and UKS data for use by all AMPTE investigators according to Article 8 of this MOU.

(PX 1027II).

cals by the IRM (Tr. 9080). Although NASA STDN stations were not used to send commands to the UKS (Tr. 15100-01), for two days NASA's Deep Space Network was used to receive data from UKS (Tr. 15104).

Based on these facts, we conclude that the three requirements imposed by § 1498(a) are present. First, NASA's launch of AMPTE UKS constituted a use of the patented invention. Second, that use was "by or for" the government. AMPTE CCE and IRM were part of a cooperative program between the United States and the Federal Republic of Germany similar to the Helios and ISEE programs discussed above. Even though AMPTE UKS was contributed by the United Kingdom pursuant to a separate agreement between the Federal Republic of Germany and the United Kingdom, we consider it to be part of the cooperative program between the United States and Germany because it was considered a subsystem of the AMPTE IRM and because the United States consented to the addition of AMPTE UKS and benefitted from its inclusion. Under these circumstances, we conclude that the government's actions were not that of a disinterested party providing launch services, but rather those of a member of a joint venture launching a spacecraft in connection with a joint project resulting in considerable mutual benefit. Thus, the government's launch of AMPTE UKS constituted a use "by or for" the government. Third, because AMPTE UKS was launched in Florida, the use occurred within the territorial limits of the United States.

Nonetheless, we conclude that AMPTE UKS may not be included in the compensation base because 35 U.S.C. § 272, which sets forth a defense to certain claims of patent infringement, applies to AMPTE

UKS. Section 272 of title 35, United States Code, provides a defense to claims of patent infringement if five conditions are met.[66] First, the invention involved must be a part of a "vessel, aircraft or vehicle." Second, the presence of the vessel, aircraft or vehicle in the United States must be "temporar[y]" or "accidental." Third, the vessel, aircraft or vehicle must be from a country that "affords similar privileges to vessels, aircraft or vehicles of the United States." Fourth, the invention must be used "exclusively for the needs of the vessel, aircraft or vehicle." Fifth, the invention must not be "sold in or used for the manufacture of anything to be sold and/or exported from the United States."

As the discussion in Part V.A.4. makes clear, spacecraft launched after 1981 are deemed to be "vehicles" within the meaning of 35 U.S.C. § 272. *See* 42 U.S.C. § 2457(k) (providing that "[a]ny object intended for launch, launched, or assembled in outer space shall be considered a vehicle for purposes of section 272"). Because AMPTE UKS was launched in 1984, the requirement that the invention be a part of a "vessel, aircraft or vehicle" is satisfied.

Second, the presence of AMPTE UKS was "temporar[y]" within the meaning of § 272. AMPTE UKS entered the United States one time for the sole purpose of being launched into outer space. In *Cali v. Japan Airlines, Inc.*, 380 F.Supp. 1120, 1126

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[66] Hughes contends that we should infer a sixth condition on the application of § 272—that the use of the invention be solely by another country and that the use be of no benefit to the United States. Hughes' argument, which is based on the legislative history of another provision—42 U.S.C. § 2457(l)—is not persuasive. Hence, we decline to infer such a requirement.

(E.D.N.Y.1974), *aff'd without op.*, 535 F.2d 1240 (2nd Cir.1975), the district court held that the presence of air carriers in the United States on a regular basis as part of an transoceanic passenger and freight service was temporary so that the carriers were not subject to the patent laws of the United States. Unlike the systematic presence of the air carriers in *Cali*, AMPTE UKS was in the United States one time for a short duration. Accordingly, we conclude that the presence of AMPTE UKS was temporary within the meaning of § 272.

Third, the United Kingdom extends "similar privileges" to "vessels, aircraft and vehicles" of the United States. The United Kingdom is a signatory to the Paris Convention, which is a treaty containing a temporary presence doctrine provision. Further, it is clear that the domestic law of the United Kingdom has had some version of the temporary presence doctrine since 1852. *See* DX 2658 (British Patents Act of 1852); DX 2661 (British Patents Act of 1949); DX 2665 (British Patents Act of 1977).[67] Accordingly, we conclude that the third requirement—that the vessel, aircraft or vehicle be from a country which extends "similar privileges" to the United States—is present.

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[67] Hughes contends that the doctrine does not apply because the United Kingdom does not have a statute making the temporary presence doctrine applicable to spacecraft. We disagree. Section 272 does not require that the United Kingdom and the United States have identical temporary presence doctrines—only that the United Kingdom have a doctrine relating to "vessels, aircraft and vehicles." Further, defendant's expert witness on United Kingdom law testified that the United Kingdom would apply its doctrine to a United States spacecraft entering the United Kingdom temporarily (Tr. 14,989-90).

There can be no dispute as to the two final requirements imposed by § 272. The invention—the attitude control system—was used exclusively for the needs of the vehicle, and the invention was not sold or used for manufacture within the United States. Accordingly, we conclude that the temporary presence doctrine, as codified in 35 U.S.C. § 272, applies, establishing a complete defense to defendant's infringement of the Williams patent by using AMPTE UKS.

4. ARIEL

The ARIEL program was a cooperative project between NASA and the Science Research Council of the United Kingdom. This portion of the opinion addresses Hughes' claim for compensation under § 1498(a) for the ARIEL 5 spacecraft.[68]

In 1970, the United States and the United Kingdom executed an MOU that outlined the responsibilities of each country and which described the scientific purpose of the project as "identifying and examining cosmic X-ray sources other than the sun" (PX 1036A). The MOU required the Science Research Council to contribute the spacecraft, to supplement NASA in providing tracking and data acquisition services and to transform data into an acceptable form and analyze the data.[69] Similarly, the MOU required

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[68] For a description of the previous four spacecraft in the ARIEL mission, see PX 1036D.

[69] The relevant portion of the MOU required the Science Research Council to:

> a. Design, fabricate, integrate, test and transport to the launch site one flight-qualified spacecraft and, as mutually agreed, flight-qualified spares of critical subsystems and hardware.

NASA to provide a launch vehicle, to "direct" the launch, to provide tracking and data acquisition services, and to cooperate with Science Research Council in analyzing the data.[70] Further, the MOU

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b. Accommodate NASA co-investigators, as mutually agreed. Their participation may contribute: (1) Ground-based or other observations to be correlated with satellite data, and/or (2) additional or modified hardware as adjuncts to existing instruments.

c. Provide and transport to the launch site agreed spacecraft ground checkout and project support equipment.

d. Test and check out flight spacecraft at launch site.

e. Supplement, as required and as feasible, NASA tracking and data acquisition services with other space tracking and data acquisition facilities.

f. Transform into computer-compatible form, tapes received from all stations, including the Satellite Tracking & Data Acquisition Network (STADAN), which have mission support responsibility.

g. Analyze the data returned by the instruments in cooperation with NASA co-investigators where appropriate, including the comparison of data and analysis of the total results.

(PX 1036A).

[70] The relevant portion of the MOU required the United States to:

a. Support U.S. co-investigators, as mutually agreed, for experiments on the British-designed, -fabricated and -integrated spacecraft, and for correlative ground-based observations.

b. Participate, as appropriate, in the fabrication, integration and testing of the U.S. co-investigator's hardware in the spacecraft

c. Review the acceptance tests of the flight units.

provided that each agency would pay the cost of discharging its responsibilities. Subsequently, by letters dated December 27, 1973 and January 28, 1974, NASA and the Science Research Council agreed to revisions of the MOU, including, among other things, a change in the launch date and launch site, and a provision that NASA would be responsible for "directing" the launch instead of "conducting" the launch (PX 1036A).

The ARIEL 5 was built in Portsmouth, England and was funded by the United Kingdom Ministry of Defense (Tr. 15027). The spacecraft was registered with the United Nations as a United Kingdom spacecraft (Tr. 15028). In accordance with the revised MOU, the spacecraft was launched by a team of Italian engineers on a Scout launch vehicle from the San Marco launch platform off the coast of Kenya, Africa on October 15, 1974. NASA supplied the launch vehicle, provided some assistance in training the Italian personnel and directed the launch of the Ariel 5 spacecraft. After launch, the United Kingdom assumed responsibility for controlling the spacecraft, and NASA's role was limited to providing a data

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> d. Provide a Scout launch vehicle and conduct the launching.
>
> e. Provide heat shield and spacecraft tie-down and separation mechanisms, as mutually agreed.
>
> f. Provide tracking and data acquisition with STADAN stations.
>
> g. Analyze cooperatively the data returned by experiments undertaken on a co-investigatorship basis and participate with the SRC in the comparison of data and analysis of the total results.

(PX 1036A).

communications link using the NASCOM and STDN systems.

The spacecraft carried six x-ray experiments—five from the United Kingdom and one from the United States. Generally, these experiments were used to conduct a systematic survey of x-ray sources both within and beyond our galaxy (the Milky Way), from above the earth's atmosphere which filters out x-rays from space and thus makes it impracticable to study x-ray sources from the ground. In particular, the experiment sponsored by the United States, the All-Sky Monitor, was an x-ray imaging device capable of monitoring the entire sky continuously for transient x-ray phenomena and, at the same time, monitoring all the strong sources in the sky for long-term effects (PX 1036D).

Based on these facts, we conclude that ARIEL 5 should not be included in the compensation base. Although the government "directed" the launch, the launch was actually conducted by a team of Italian engineers off the coast of Africa. Hence, we must address whether ARIEL 5 was used within the territorial boundaries of the United States. The only nexus with the physical territory of the United States was that NASA STDN systems located around the world, but headquartered at Goddard Space Center, Greenbelt, Maryland, were used.[71] In our view, that fact, by itself, is insufficient to establish liability for use within the United States.

If the United States government had actually originated the commands within the United States and then transmitted those commands to the satellite

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[71] The ground stations used for ARIEL-5 were in Quito, Ecuador, Ascension Island and Guam (Tr. 15136).

through its STDN system, we would find "use" within the United States. The fact that those functions were separated, with the government providing only tracking and data acquisition services, undercuts plaintiff's argument that the patent was used within United States territory. It is important to note that unlike the other four "foreign" spacecraft in issue, the ARIEL 5 spacecraft never entered the United States.[72] That fact, combined with the absence of direct control from United States territory, suggests that any connection with the United States was attenuated. More important, though, is the fact that the so- called "home territory" or "master station" was not in the United States.

The Court of Claims recognized that if an invention is an instrumentality that necessarily extends beyond the United States with a control point in the United States, the "use" is deemed to occur here. In *Decca Limited v. United States*, 210 Ct.Cl. 546, 552-53, 544 F.2d 1070, 1074-75 (1976), the court addressed the problem of applying § 1498 to an allegedly infringing system that necessarily operated in more than one country. That case involved a worldwide radio navigation system with two stations in the United States and one station in Norway. Because the "master" station was in the United States, the court found that the system was "used" in United States territory:

At any rate, the whole Omega system must be deemed, at least for purposes of litigating the patent here involved, to be a unity and the location of that unity must be deemed to be in United States terri-

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[72] A mock-up was sent to the United States for purposes of integration with the launch vehicle.

tory. Here it has planted several of its feet, and use of United States territory is indispensable to it. The location of facilities in some foreign countries is also essential to the plan, but the selection of any single other country is, apparently, not essential. Any one such country could readily be abandoned for another.

Id. at 554, 544 F.2d at 1075. In a case involving the date on which a device for orienting a spacecraft was first reduced to practice, *Rosen v. NASA*, 152 U.S.P.Q. 757, 768 (1966), the United States Patent Office Board of Patent Interferences declared: "[W]e are inclined to view the operation of the integrated instrumentality including parts of the satellite and its control point, the latter being in the United States [Goddard Space Center], as not removed from the United States by reason of the satellite being necessarily distant from the several states of the United States." Accordingly, the board concluded that the patent was reduced to practice within the United States for purposes of 35 U.S.C. § 102(g). Unlike the Williams patent, the patent involved in *Rosen* covered the ground control device. Accordingly, the holding that the device was reduced to practice within the United States has somewhat greater force than does Hughes' argument concerning use within territorial limits in the instant case. Further, unlike the facts in *Decca* and *Rosen*, the "control point" or "master station" for ARIEL 5 was not located in the United States. Although Goddard Space Center was the central communications link for tracking and data acquisition services, the "control point" for the spacecraft itself was in England.

Accordingly, even though the ARIEL program was similar to the Helios and ISEE programs in that it was a cooperative joint project between the United

States and other governments, the fact that any use by or for the United States occurred beyond the boundaries of the United States renders the patent laws inapplicable and thus obviates any liability under § 1498.

5. Conclusion

Part V has addressed the government's liability under § 1498(a) for five spacecraft associated with four international spacecraft programs. The primary issues were whether the government used each of the spacecraft, whether that use was "by or for" the government and whether the use occurred within United States borders. We conclude that the government is liable under § 1498(a) for three of the spacecraft, Helios A and B and ISEE B, and that the government is not liable under that provision for two of the spacecraft, AMPTE UKS and ARIEL 5.

VI

The foregoing portion of this opinion resolves all heretofore undetermined liability issues in this litigation. The appendix to this opinion lists all of the 108 spacecraft accused at any stage of the case and provides references to the liability disposition for each spacecraft.

There will follow an opinion addressing all previously unresolved issues pertaining to costs, compensation base, royalty rate and delay damages. Judgment shall be withheld pending resolution of all damages issues.

/s/ JAMES T. TURNER
JAMES T. TURNER
Judge

HUGHES AIRCRAFT COMPANY V. UNITED STATES AMERICA
No OF. 426-73

APPENDIX TO OPINION

This appendix contains a complete list of the 108 spacecraft accused at any stage of this litigation, together with (1) an indication for each accused item whether liability for a taking under 28 U.S.C. § 1498 has been found, (2) a citation to the record for the liability determination, (3) a statement of the taking date (where applicable) and (4) an indication of the major (but by no means exclusive) issue concerning liability.

	SPACECRAFT	TAKING LIABILITY	CITE	TAKING DATE	MAJOR ISSUE
1.	ACTS (Advanced Communications Technology Satellite) (1)	No	conceded[1]		
	AE (Atmosphere Explorer) (3)				
2.	C	No	This op.		Doctr. of Equiv.
3.	D	No	This op.		Doctr. of Equiv.
4.	E	No	This op.		Doctr. of Equiv.
	AMPTE (Active Magnetospheric Particle Tracer Explorer) (3)				
5.	CCE	Yes	conceded[2]	08/16/84	

[1] ACTS: T. 18,955 (Karon), dated 01/15/91.

[2] AMPTE CCE: Defendant's Objections and Partial Answers to Plaintiff's Requests for Admission and Further Inter-

SPACECRAFT	TAKING LIABILITY	CITE	TAKING DATE	MAJOR ISSUE
6. IRM	No	conceded[3]		
7. UKS	No	This op.		Temp. Presence
8. ARIEL-5 (UK-5) (1)	No	This op.		Use
9. CRRES (Combined Release and Radiation Effects Satellite) (1)	Yes	Bench rl.[4]	03/31/87	Manufacture
10. CTS (Communications Technology Satellite) (1)	Yes	Bench rl.[5]	01/17/76	Implied lic.

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rogatories, dated 12/01/87 (PX 1384J), Response to No. 30, p. 32a (stating that defendant will not contest the issue of claim readability; spacecraft was made by or for the United States with its authorization and consent); bench ruling, T. 9273-80 (Turner, J.), dated 08/19/88 (holding that defendant should be held to statements in responses to requests for admissions, with certain exceptions outlined in Appendix G); bench ruling, T. 17,153 (Turner, J.), dated 02/28/89 (holding that canted thrusters do not avoid infringement).

[3] AMPTE IRM: "Plaintiff's Brief and Argument on Infringement and Other Issues" filed 02/15/89, at 112. Although plaintiff concedes noninfringement, plaintiff alleges that AMPTE IRM should be included in the compensation base with respect to AMPTE CCE under the "entire market value rule." *Id.*

[4] CRRES: T. 18,084-85 (Turner, J.), dated 06/16/89.

[5] CTS: T. 18,084-85 (Turner, J.), dated 06/16/89. See T. 17,330-33; 17,343-45.

SPACECRAFT	TAKING LIABILITY	CITE	TAKING DATE	MAJOR ISSUE
DSCS II (Defense Satellite Communications System II) (17)				
11. QTV[6]	Yes	conceded[7]	09/11/73	Doctr. of Equiv.

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[6] All QTV's (Qualification Test Vehicles), i.e., DSCS II QTV, FLTSTCM QTV and GPS QTV, were subject of bench ruling that a taking occurs when a qualification test vehicle is manufactured that incorporates the patented device: T. 16,968-70 (Turner, J.), dated 02/02/89. Thus, if liability is established for a particular spacecraft and the qualification test vehicle for that spacecraft similarly incorporates the patented invention, then liability is also established for the qualification test vehicle.

[7] DSCS II QTV and FV 5-16; only four DSCS II satellites were initially accused in the "liability" phase (i.e., DSCS II FV 1-4). The Federal Circuit held that these four DSCS II satellites infringed the Williams patent. *Hughes Aircraft v. United States*, 717 F.2d 1351 (Fed.Cir.1983). Since the attitude control systems of DSCS II QTV and FV 5-16 are identical to those of DSCS II FV 1-4, defendant conceded that DSCS II QTV and FV 5-16 also infringed the Williams patent; Defendant's Objections and Partial Answers to Plaintiff's Requests for Admission and Further Interrogatories, dated 12/01/87 (PX 1384J), Response to No. 37, p.54a (stating that defendant will not contest the issue of claim readability; spacecraft was made by or for the United States with its authorization and consent); bench ruling, T. 9273-80 (Turner, J.), dated 08/19/88 (holding that defendant should be held to statements in responses to requests for admissions, with certain exceptions outlined in Appendix G); bench ruling, T. 17,153 (Turner, J.) (holding that canted thrusters do not avoid infringement).

SPACECRAFT		TAKING LIABILITY	CITE	TAKING DATE	MAJOR ISSUE
12.	FV 1	Yes	Fed.Cir.[8]	09/11/73	Doctr. of Equiv.
13.	FV 2	Yes	Fed.Cir.	09/11/73	Doctr. of Equiv.
14.	FV 3	Yes	Fed.Cir.	11/06/73	Doctr. of Equiv.
15.	FV 4	Yes	Fed.Cir.	11/06/73	Doctr. of Equiv.
16.	FV 5	Yes	conceded	04/09/75	Doctr. of Equiv.
17.	FV 6	Yes	conceded	04/09/75	Doctr. of Equiv.
18.	FV 7	Yes	conceded	05/12/77	Doctr. of Equiv.
19.	FV 8	Yes	conceded	05/12/77	Doctr. of Equiv.
20.	FV 9	Yes	conceded	02/08/78	Doctr. of Equiv.
21.	FV 10	Yes	conceded	02/08/78	Doctr. of Equiv.
22.	FV 11	Yes	conceded	10/05/78	Doctr. of Equiv.
23.	FV 12	Yes	conceded	10/05/78	Doctr. of Equiv.
24.	FV 13	Yes	conceded	10/18/79	Doctr. of Equiv.
25.	FV 14	Yes	conceded	10/18/79	Doctr. of Equiv.

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[8] DSCS II FV 1-4; *Hughes Aircraft v. United States*, 717 F.2d 1351 (Fed.Cir.1983). This case citation applies to all references to "Fed.Cir." in this appendix.

SPACECRAFT	TAKING LIABILITY	CITE	TAKING DATE	MAJOR ISSUE
26. FV 15	Yes	conceded	03/28/80	Doctr. of Equiv.
27. FV 16	Yes	conceded	09/25/80	Doctr. of Equiv.
ESA/GEOS (Geodynamics Experimental Ocean Satellite) (2)				
28. A/1	No	Claims withdrawn by joint stipulation filed August 4, 1993 approved by order dated August 6, 1993.		
29. B/2	No			
FLTSTCM (Fleet Satellite Communications) (9)				
30. QTV	Yes	conceded[9]	02/06/78	
31. FV 1	Yes	conceded	12/01/77	
32. FV 2	Yes	conceded	03/29/79	
33. FV 3	Yes	conceded	10/29/79	
34. FV 4	Yes	conceded	09/22/80	
35. FV 5	Yes	conceded	06/28/81	
36. FV 6	Yes	conceded	04/13/86	
37. FV 7	Yes	conceded	09/28/86	
38. FV 8	Yes	conceded	03/12/87	

[9] FLTSTCM QTV and FV 1-8; Defendant's Objections and Partial Answers to Plaintiff's Requests for Admission and Further Interrogatories, dated 12/01/87 (PX 1384J), Response to No. 38, p. 59a (stating that defendant will not contest the issue of claim readability; spacecraft was made by or for the United States with its authorization and consent); bench ruling, T. 9273-80 (Turner, J.), dated 08/19/88 (holding that defendant should be held to statements in responses to requests for admissions, with certain exceptions outlined in Appendix G); bench ruling, T. 17,153 (Turner, J.), (holding that canted thrusters do not avoid infringement).

SPACECRAFT	TAKING LIABILITY	CITE	TAKING DATE	MAJOR ISSUE
39. GALILEO (1)	No	This op.		Doctr. of Equiv.
GOES (Geostationary Operational Environmental Satellites) (2)				
40. B	No	Ford settl.[10]		
41. C	No	Ford settl.		
GPS (Global Positioning System) (40)				
42. QTV[11]	Yes	conceded[12]	09/22/77	

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[10] GOES B and C: "Ford settl." refers to a final settlement agreement between Hughes Aircraft and Ford Aerospace, dated 09/10/87. Ford manufactured 13 specific spacecraft for the United States. In *Hughes Aircraft v. United States*, 15 Cl.Ct. 550 (1988) this court held that Hughes released Ford customers and users of Ford products from infringement claims regarding the Williams patent. *Id.* at 555. Therefore, Hughes' claims against the government concerning the 13 satellites are barred as a matter of law. *Id.*

[11] GPS QTV eventually was modified and became GPS FV 6. Thus, GPS QTV and GPS FV 6 are counted as one satellite for liability purposes, but two different taking dates are relevant when calculating damages.

[12] GPS FV 1-14, 16, 17 and 19: Defendant's Objections and Partial Answers to Plaintiff's Requests for Admission and Further Interrogatories, dated 12/01/87 (PX 1384J), Response to No. 42, p. 74a (stating that defendant will not contest the issue of claim readability for GPS spacecraft; defendant concedes that launched GPS satellites were made by or for the United States with its authorization and consent, however defendant alleges that GPS spacecraft that have not been launched avoid liability); bench ruling, T. 9273-80 (Turner, J.), dated 08/19/88 (holding that defendant should be held to statements in responses to requests for admissions, with certain

	SPACECRAFT	TAKING LIABILITY	CITE	TAKING DATE	MAJOR ISSUE
43.	FV 1	Yes	conceded	02/22/78	
44.	FV 2	Yes	conceded	03/31/78	
45.	FV 3	Yes	conceded	10/06/78	
46.	FV 4	Yes	conceded	11/06/78	
47.	FV 5	Yes	conceded	11/30/80	
	FV 6[13]	Yes	conceded	04/30/81	
48.	FV 7	Yes	conceded	01/07/80	
49.	FV 8	Yes	conceded	03/28/80	
50	FV 9	Yes	conceded	07/30/84	
51.	FV 10	Yes	conceded	06/02/83	
52.	FV 11	Yes	conceded	01/27/84	
53.	FV 12	Yes	conceded	01/24/86	
	FV 12 (imp.)[14]	Yes	conceded	01/24/86	
54.	FV 13	Yes	conceded	04/24/87	
55.	FV 14	Yes	conceded	12/18/87	
56.	FV 15	Yes	conceded[15]	06/26/90	
57.	FV 16	Yes	conceded	12/18/87	
58.	FV 17	Yes	conceded	04/20/88	
59.	FV 18	Yes	conceded	08/17/89	

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exceptions outlined in Appendix G); bench ruling, T. 17,153 (Turner, J.) (holding that canted thrusters do not avoid infringement).

[13] See note 11 *supra*.

[14] GPS FV 12 was the subject of two different contracts, hence the distinction between FV 12 and FV 12 (improved). GPS FV 12 and FV 12 (improved) are considered as one spacecraft for liability purposes. Further, plaintiff has stipulated to a single taking date for calculating damages (Pl. Br., June 9, 1989, p. 85).

[15] GPS FV 15, 18, 20, 21 and 23: Defendant's Appendix G Submission for Phase II of the Accounting Trial, Part I Memorandum of Contentions of Applicable Fact and Law, filed 01/07/91, p. 2.

	SPACECRAFT	TAKING LIABILITY	CITE	TAKING DATE	MAJOR ISSUE
60.	FV 19	Yes	conceded	06/30/88	
61.	FV 20	Yes	conceded	12/18/89	
62.	FV 21	Yes	conceded	10/13/89	
63.	FV 22	Yes	This op.	09/11/90	Manufacture
64.	FV 23	Yes	conceded	06/26/90	
65.	FV 24	Yes	This op	09/11/90	Manufacture
66.	FV 25	Yes	This op.	09/11/90	Manufacture
67.	FV 26	Yes	This op.	09/11/90	Manufacture
68.	FV 27	Yes	This op.	09/11/90	Manufacture
69.	FV 28	Yes	This op.	09/11/90	Manufacture
70.	FV 29	Yes	This op.	09/11/90	Manufacture
71.	FV 30	Yes	This op.	09/11/90	Manufacture
72.	FV 31	Yes	This op.	09/11/90	Manufacture
73.	FV 32	Yes	This op.	09/11/90	Manufacture
74.	FV 33	Yes	This op.	09/11/90	Manufacture
75.	FV 34	Yes	This op.	09/11/90	Manufacture
76.	FV 35	Yes	This op.	09/11/90	Manufacture
77.	FV 36	Yes	This op.	09/11/90	Manufacture

	SPACECRAFT	TAKING LIABILITY	CITE	TAKING DATE	MAJOR ISSUE
78.	FV 37	No	conceded[16]		Manufacture
79.	FV 38	No	conceded		Manufacture
80.	FV 39	No	conceded		Manufacture
81.	FV 40	No	conceded		Manufacture
	HELIOS (2)				
82.	A	Yes	This op.	12/10/74	Use
83.	B	Yes	This op.	01/15/76	Use
	IMP (Interplanetary Monitoring Platform) (2)				
84.	H	Yes	Fed. Cir.	09/11/73	Doctr. of Equiv.
85.	J	Yes	Fed. Cir.	10/25/73	Doctr. of Equiv.
	ISEE (International Sun-Earth Explorer) (3)				
86.	A	Yes	conceded[17]	10/22/77	

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[16] GPS FV 37-40: T. 18,955 (Karon), dated 01/15/91.

[17] ISEE-A: Defendant's Objections and Partial Answers to Plaintiff's Requests for Admission and Further Interrogatories, dated 12/01/87 (PX 1384J), Response to No. 45, p. 81a (stating that defendant will not contest the issue of claim readability; the spacecraft was made by or for the United States with its authorization and consent); bench ruling, T. 9273-80 (Turner, J.), dated 08/19/88 (holding that defendant should be held to statements in responses to requests for admissions, with certain exceptions outlined in Appendix G); bench ruling, T. 17,153 (Turner, J.) (holding that canted thrusters do not avoid infringement).

SPACECRAFT		TAKING LIABILITY	CITE	TAKING DATE	MAJOR ISSUE
87.	B	Yes	This op.	10/22/77	Use
88.	C	Yes	conceded[18]	08/12/78	
89.	IUE-A (International Ultraviolet Explorer) (1)	Yes	conceded[19]	01/26/78	
	NATO (6)				
90.	II A	No	Ford settl.(Yes/Fed.Cir.)		
91.	II B	No	Ford settl. (Yes/Fed.Cir.)		
92.	III A	No	Ford settl.		
93.	III B	No	Ford settl.		
94.	III C	No	Ford settl.		

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[18] ISEE-C: Defendant's Objections and Partial Answers to Plaintiff's Requests for Admission and Further Interrogatories, dated 12/01/87 (PX 1384J), Response to No. 47, p. 86a (stating that defendant will not contest the issue of claim readability; spacecraft was made by or for the United States with its authorization and consent); bench ruling, T. 9273-80 (Turner, J.), dated 08/19/88 (holding that defendant should be held to statements in responses to requests for admissions, with certain exceptions outlined in Appendix G); bench ruling, T. 17,153 (Turner, J.) (holding that canted thrusters do not avoid infringement).

[19] IUE-A: Defendant's Objections and Partial Answers to Plaintiff's Requests for Admission and Further Interrogatories, dated 12/01/87 (PX 1384J), Response to No. 48, p. 88a (stating that defendant will not contest the issue of claim readability; spacecraft was made by or for the United States with its authorization and consent); bench ruling, T. 9273-80 (Turner, J.), dated 08/19/88 (holding that defendant should be held to statements in responses to requests for admissions, with certain exceptions outlined in Appendix G); bench ruling, T. 17,153 (Turner, J.) (holding that canted thrusters do not avoid infringement).

	SPACECRAFT	TAKING LIABILITY	CITE	TAKING DATE	MAJOR ISSUE
95.	III D	No	Ford settl.		
96.	NTS-2 (Navigation Technology Satellite) (1)	Yes	conceded[20]	06/23/77	
	PIONEER (2)				
97.	10	Yes	Fed.Cir.	09/11/73	
98.	11	Yes	Fed.Cir.	09/11/73	
	SKYNET (2)				
99.	II A	No	Ford settl. (Yes/Fed.Cir.)		
100.	II B	No	Ford settl. (Yes/Fed.Cir.)		
	SMS (Synchronous Meteorological Satellite) (3)				
101.	A	No	Ford settl.		
102.	B	No	Ford settl.		
103.	C[21]	No	Ford settl.		
	SOLRAD (Solar Radiation Spacecraft) (4)				
104.	9	Yes	Fed.Cir.	09/11/73	
105.	10	Yes	Fed.Cir.	09/11/73	
106.	11A	Yes	conceded[22]	03/14/76	

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[20] NTS-2: Defendant's Objections and Partial Answers to Plaintiff's Requests for Admission and Further Interrogatories, dated 12/01/87 (PX 1384J), Response to No. 51, p. 95a (stating that defendant will not contest the issue of claim readability; spacecraft was made by or for the United States with its authorization and consent); bench ruling, T. 9273-80 (Turner, J.), dated 08/19/88 (holding that defendant should be held to statements in responses to requests for admissions, with certain exceptions outlined in Appendix G); bench ruling, T. 17,153 (Turner, J.), (holding that canted thrusters do not avoid infringement).

[21] Also referred to as "GOES A."

SPACECRAFT	TAKING LIABILITY	CITE	TAKING DATE	MAJOR ISSUE
107. 11B	Yes	conceded	03/14/76	
108. STP 78-2 (SCATHA) (Spacecraft Charging at High Altitude) (1)	Yes	conceded[23]	10/26/78	

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[22] SOLRAD 11A and 11B: Defendant's Objections and Partial Answers to Plaintiff's Requests for Admission and Further Interrogatories, dated 12/01/87 (PX 1384J), Response to No. 56, p. 107a (stating that defendant will not contest the issue of claim readability; spacecraft were made by or for the United States with its authorization and consent); bench ruling, T. 9273-80 (Turner, J.), dated 08/19/88 (holding that defendant should be held to statements in responses to requests for admissions, with certain exceptions outlined in Appendix G); bench ruling, T. 17,153 (Turner, J.) (holding that canted thrusters do not avoid infringement).

[23] STP 78-2: Defendant's Objections and Partial Answers to Plaintiff's Requests for Admission and Further Interrogatories, dated 12/01/87 (PX 1384J), Response to No. 57, p. 111a (stating that defendant will not contest the issue of claim readability; spacecraft were made by or for the United States with its authorization or consent); bench ruling, T. 9273-80 (Turner, J.), dated 08/19/88 (holding that defendant should be held to statements in responses to requests for admissions, with certain exceptions outlined in Appendix G); bench ruling, T. 17,153 (Turner, J.) (holding that canted thrusters do not avoid infringement).

APPENDIX C

UNITED STATES COURT OF APPEALS
FOR THE FEDERAL CIRCUIT

Appeal No. 426-73

HUGHES AIRCRAFT COMPANY, APPELLANT

v.

THE UNITED STATES, APPELLEE

Sept. 20, 1983

Before: MARKEY, Chief Judge, and DAVIS and BALDWIN, Circuit Judges.

MARKEY, Chief Judge.

Hughes Aircraft Company (Hughes) appeals that part of a judgment[1] of the United States Claims Court finding non-infringement of U.S. patent No. 3,758,051 (the Williams patent) by the government's "store and execute" (S/E) spacecraft. The government appeals that part of the judgment holding claims 1, 2, and 3 of the patent valid. We affirm-in-part, reverse-in-part, and remand for a determination of the quantum of recovery for infringement by the accused SKYNET

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[1] Pursuant to an October 4, 1982 order of this court, the trial judge entered a final judgment on October 8, 1982, corresponding to the decision recommended in this case.

II, NATO II, DSCS II, IMP (H and J), SOLRAD (9 and 10), and PIONEER (10 and 11)[2] spacecraft.

The Williams patent for "Velocity Control and Orientation of a Spin-Stabilized Body", issued to Donald D. Williams on September 11, 1973, on application serial No. 391,187, filed August 21, 1964, a continuation-in-part of now- abandoned application serial No. 22,733, filed April 18, 1960.

Background

Throughout the late 1950's and early 1960's, the Department of Defense and the National Aeronautics and Space Administration (NASA) engaged in an intense effort to build a synchronous communications satellite with an orbital period equalling the rotational period of the earth. The goal was a satellite moving in a west-to-east orbit with a radius of 22,750 nautical miles and having a linear velocity of 10,090 feet per second, so that it could "hover" above a fixed point on earth.

Despite huge expenditures, the government never solved the technical problem of attitude control. That problem is described as the need to orient the satellite in space, without exceeding weight limitations, while insuring that (1) its directional antennas were always pointed toward the earth, and (2) that it would obtain a reliable, adequate fuel supply from the sun.

Working for Hughes, Williams solved the problem. He created a practical system for attitude control of a spin-stabilized satellite. In the Williams system, sig-

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[2] PIONEER, initially expected to function for 21 months, continued its galactic journey for 11 years. It has recently become the first man-made structure known to have entered "deep" space as it continues its journey toward infinity. *Washington Post*, June 13, 1983.

nals sent by a ground crew control the satellite by causing a jet on the satellite to pulse at a selected satellite position in successive spin cycles, thereby "precessing" the satellite in a selected direction. Williams taught how a jet valve on the satellite's periphery could discharge gas in brief, successive pulses on command. He taught that an on-board V-beam sun sensor (vertical slit and canted slit) could collect raw data from the sun and transmit it to earth, enabling a ground crew to determine the satellite's existing and desired orientations.

When, using conventional radio signals, the ground crew pulses the attitude jet, torque is applied to the satellite and its spin axis is "precessed" parallel to the earth's axis, causing the beam of the satellite's antenna to point to the earth continuously during the 24-hour period of each orbit, and insuring that the satellite's solar cells receive maximum light from the sun.

[Image omitted, see 717 F.2d at 1353]

The Williams Satellite

On April 2, 1960, Williams successfully operated a laboratory model, known as the "dynamic wheel", in demonstration of his invention. See *Williams v. Administrator of NASA*, 463 F.2d 1391, 1395-96, 175 USPQ 5, 8-9 (Cust. & Pat.App.1972), *cert. denied*, 412 U.S. 950, 93 S.Ct. 3013, 37 L.Ed.2d 1003 (1973).

Hughes disclosed the invention to NASA, seeking its participation in building a satellite with the unique attitude control system. In its "Sole Source Justification", NASA stated:

> Hughes has submitted the only proposal to NASA indicating that a 24-hour lightweight synchronous satellite having a two-way voice communication capability is practicable. This design is achieved through the use of a unique attitude and orbital velocity vernier system which allows an optimized communication system to meet the requirements for two-way voice communication within the weight limitations.
>
> Utilization of the development team and design approaches established at Hughes will result in a savings in time and money to the Government. It is therefore recommended that a sole source procurement of a spacecraft for Project SYNCOM be awarded to Hughes Aircraft Corporation.

In August, 1961, Hughes and NASA entered a contract for engineering and construction of the SYNCOM satellite. On July 26, 1963, SYNCOM II, the world's first synchronous communications satellite, was launched and placed in orbit. On July 31, 1963, the attitude control system was successfully employed and radio transmission continued 24 hours per day.

On April 18, 1960, Williams had filed the parent application of that which resulted in the Williams patent. The examiner allowed some claims, but rejected others based on prior art and an inadequate disclosure of ground control apparatus. Williams' proffered amendments were denied entry as containing new matter.

On August 21, 1964, Williams filed a continuation-in-part (CIP) application. The CIP added to the parent disclosure a Figure 12 and a description of the structure it illustrated, i.e., a ground-based analog

controller for synchronizing the force applied to the satellite with the satellite's spin cycle.

On January 10, 1966, the examiner rejected all claims under 35 U.S.C. § 103 as unpatentable over earlier cited art and newly cited U.S. patent No. 3,216,674 entitled "Proportional Navigation System for a Spinning Body in Free Space", issued November 9, 1965 to McLean and disclosing a spin-stabilized, target-seeking space vehicle having a jet motor on its periphery. The motor, controlled by an infrared sensor, automatically precessed the vehicle to keep its spin axis pointed toward the target.

The McLean vehicle for steering a collision course to a target is self-contained and self-guiding. When the target is aligned with the vehicle's spin axis, photodetector 22 detects a constant infrared radiation, producing a constant signal. If the target moves from alignment, detector 22 provides an alternating signal, to fire precessing jet 16 at the point in the vehicle's spin cycle that will precess the spin axis back toward the target.

[Image omitted, see 717 F.2d at 1355]

The McLean Space Vehicle

By amendment filed April 29, 1966, Williams canceled the rejected broad claims and inserted three independent claims that became claims 1-3 of the patent in suit. Representative claim 1 reads:

1. Apparatus comprising:

   a. a body adapted to spin about an axis;

   b. fluid supply means associated with said body;

c. a valve connected to said fluid supply means;

d. fluid expulsion means disposed on said body and coupled with said valve and oriented to expel said fluid substantially along a line parallel to said axis and separated therefrom;

e. means disposed on said body for providing an indication to a location external to said body of the instantaneous spin angle position of said body about said axis and the orientation of said axis with reference to a fixed external coordinate system;

f. and means disposed on said body for receiving from said location control signals synchronized with said indication;

g. said valve being coupled to said last-named means and responsive to said control signals for applying fluid to said fluid expulsion means in synchronism therewith for precessing said body to orient said axis in a predetermined desired relationship with said fixed external coordinate system.

In accompanying remarks, Williams said "[t]hese claims were re-written . . . so that the claims more clearly distinguish over the newly-cited reference, McLean" and "[a]s to McLean, he does not teach or suggest the elements and relationships set out in [paragraphs (e), (f), and (g)]". Placing emphasis on paragraph (e), Williams said: "McLean's infrared telescope does not indicate the instantaneous spin angle position of his body *with reference to a fixed external coordinate system, and it does not indicate*

the orientation of the axis with reference to a fixed external coordinate system. [Emphasis in original.]" On May 4, 1966, the examiner allowed the claims.

The Administrator of NASA asserted that he was entitled to receive the patent, on behalf of the United States, pursuant to § 305 of the National Aeronautics and Space Act, 42 U.S.C. § 2457. The Patent Office Board of Patent Interferences agreed, viewing the launching and maneuvering of SYNCOM II accomplished under government contract as constituting the first actual reduction to practice of the invention. The Court of Customs and Patent Appeals reversed, holding that the earlier, successful operation of the "dynamic wheel" had

> unquestionably met the requirements for actual reduction to practice. Hughes' experts promptly adapted the present attitude control system in place of a different system originally planned for its Comsat program, which it was offering to government agencies and others. NASA, obviously as the result of consideration by its technical staff and advisors of the program and the Hughes activities under it, including the dynamic wheel test, entered into the 1961 contract for the Syncom program at the risk of millions of dollars.
>
> For the above reasons, we conclude that the invention was actually reduced to practice before, and outside of, the NASA contract and that the board's determination to the contrary was erroneous. [*Williams v. Administrator of NASA*, 463 F.2d at 1399-1400, 175 USPQ at 11, footnote omitted.]

In the Administrator's brief in the Court of Customs and Patent Appeals, he referred to the Williams invention as "an invention in a sophisticated art, involving new and unobvious subject matter". In his Petition for Writ of Certiorari filed with the Supreme Court, he characterized the patent in suit as "an important patent on an invention used in space satellites".

On September 11, 1973, the Williams patent issued, with Hughes as assignee. On November 13, 1973, Hughes filed this action in the Court of Claims under 28 U.S.C. § 1498, seeking reasonable and entire compensation for the unauthorized manufacture or use by the United States of the claimed invention in the government's SKYNET II, NATO II, DSCS II, IMP (H and J), SOLRAD (9 and 10), and PIONEER (10 and 11) spacecraft. The government disputed validity and denied infringement.

The trial judge submitted a recommended decision and conclusion of law, *Hughes Aircraft Co. v. United States*, 205 USPQ 381 (Trial Div., Ct.Cl.1979), finding that: (1) the ground controller shown in Figure 12 of the patent was an element of all three claims; (2) those claims were restricted to the filing date of the CIP application and were not entitled to the benefit of the parent application's filing date, because the parent provided inadequate support under 35 U.S.C. §§ 120 and 112, first paragraph; and (3) the claims were invalid under 35 U.S.C. § 102(b), because the invention claimed had been described in a printed publication more than one year before the filing date of the CIP

application.[3] In *Hughes Aircraft Co. v. United States*, 640 F.2d 1193, 1195, 208 USPQ 785, 788 (1980), the Court of Claims rejected the trial judge's conclusion, stating "[t]he claims of the patent cover solely the orbiting satellite and no other object, device, means or apparatus." The court held that "The Williams patent is not invalid under 35 U.S.C. § 102(b)." The case was

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[3] The relevant statutory provisions are:

§ 120. Benefit of earlier filing date in the United States.

An application for patent for an invention disclosed in the manner provided by the first paragraph of section 112 of this title in an application previously filed in the United States, or as provided by section 363 of this title, by the same inventor shall have the same effect, as to such invention, as though filed on the date of the prior application, if filed before the patenting or abandonment of or termination of proceedings on the first application or on an application similarly entitled to the benefit of the filing date of the first application and if it contains or is amended to contain a specific reference to the earlier filed application.

§ 112. *Specification*

The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention.

§ 102. *Conditions for patentability; novelty and loss of right to patent*

A person shall be entitled to a patent unless—

. . .

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of the application for patent in the United States . . .

remanded for a recommended decision and findings on the other issues presented. *Id.* at 1199, 208 USPQ at 791.

Decision on Remand

On September 1, 1982, the trial judge submitted a recommended decision and conclusion of law on remand. *Hughes Aircraft Company v. United States*, 215 USPQ 787. In an exhaustive opinion, he rejected the defense of invalidity under 35 U.S.C. § 112, held that the claimed subject matter would have been nonobvious under 35 U.S.C. § 103,[4] and found that the patent is infringed by the accused "real-time" spacecraft but not by the accused S/E spacecraft. Specifically, he found that claim 1 is infringed by the SOLRAD (9 and 10) and PIONEER (10 and 11) "real-time" spacecraft, and that no claim is infringed by the SKYNET II, NATO II, DSCS II, or IMP (H and J) S/E spacecraft.

The trial judge acknowledged the similarities between the S/E spacecraft and the Williams satellite:

> The store and execute systems have many elements that are similar, if not identical, to the system described in the Williams patent. Each of

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[4] 35 U.S.C. § 103 reads:

§ 103. *Conditions for patentability; non-obvious subject matter*

A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

> the systems includes (1) a spin-stabilized spacecraft; (2) means for determining the orientation of the spin axis of the spacecraft from the earth; (3) means for signaling from the earth to the spacecraft that a change in orientation is desired; (4) a precession jet mounted on the spacecraft offset from the spin axis; and (5) means for pulsing the offset jet in synchronism with the spin of the spacecraft so that the spin axis is precessed in the desired direction. The Williams system includes all of these elements. [215 USPQ at 807]

Nonetheless, in concluding that no claim is infringed by the accused S/E spacecraft, he emphasized the literal language of the claims:

> [I]t is basic in patent law that the claims . . . define the scope of invention. 35 U.S.C. § 112, second paragraph. No matter how fair or equitable it may seem, a court cannot rewrite the claims. *Autogiro Co. of America v. United States*, 181 Ct.Cl. 55, 60, 384 F.2d 391, 396, 155 USPQ 697, 701 (1967). [215 USPQ at 807]

He found that Williams' claims require: (1) means for providing to an external location information sufficient to determine the instantaneous spin angle (ISA) position; and (2) means for pulsing the precession jet within a fixed time after receipt of a control signal from that location. Finding that the SKYNET II, NATO II, and DSCS II spacecraft contain neither of those requirements, and the IMP (H and J) spacecraft do not contain the latter, he concluded that no S/E spacecraft literally infringes the claims.

Respecting Hughes' reliance on the doctrine of equivalents, the trial judge said:

> As plaintiff included these elements in the claims to overcome the prior art [the McLean patent], plaintiff is now estopped from claiming that these elements are unnecessary to avoid the art

and

> In view of the file wrapper estoppel in this case, the doctrine of equivalents affords protection only against alleged infringers who use obvious and exact equivalents of the elements of the claimed invention. There is no obvious or exact equivalent of plaintiff's means for providing an indication of the ISA to an external location in either [sic] of the SKYNET II, NATO II or DSCS II systems. Nor is there an obvious or exact equivalent of the means for pulsing the precession jet within a fixed time period after the receipt of a control signal in any of the accused store and execute systems. [215 USPQ at 812]

Accordingly, he concluded that none of the accused S/E spacecraft infringes any of the Williams patent claims.

The government has not appealed from the judgment that the SOLRAD and PIONEER spacecraft infringe claim 1 of the patent in suit. It does argue invalidity of the Williams patent, however, and if the patent be held invalid, the infringement judgment would fall, liability for infringement of an invalid patent being non-existent in law.

Issues

I. Whether the Williams patent is invalid because a parent application did not comply with 35 U.S.C. § 112, first paragraph.

II. Whether Williams' claimed subject matter would have been obvious, 35 U.S.C. § 103.

III. Whether Williams' claims are infringed by any of the accused "store and execute" spacecraft.

OPINION

I. Validity

(A) *35 U.S.C. §§ 112, 120, 102(b)*

The government argument that the Williams patent is invalid because a parent application was not enabling under 35 U.S.C. § 112 relies on this language in the previous Court of Claims opinion, *Hughes Aircraft Co. v. United States*, 640 F.2d at 1198, 208 USPQ at 790:

> The problem with the original [parent] application with respect to the ground control device was not the failure to *claim* such a device (since it was not a part of the invention), but to give sufficient information regarding the ground control device to enable one skilled in the art to practice the invention.
>
> It was this deficiency in the information about the ground control device contained in the original application that the amplification of the specifications in the CIP application was designed to correct [Emphasis in original].

The government couches this defense in traditional terms, i.e., "failure to comply with § 112, first paragraph". It makes no effort however, nor could it, to

show that the Williams patent fails to comply with § 112. As above indicated, it is necessary that Williams be entitled to his parent application's filing date under § 120, if he is to avoid the effect of the publication under § 102(b). The government, in asserting non-entitlement to the earlier date, is thus attempting to relitigate the § 102(b) issue. That it cannot do.

Whatever may be said of the language the government relies on, that language cannot be considered in a vacuum or out of context. The Court of Claims expressly held that "The Williams patent is not invalid under 35 U.S.C. § 102(b)", *Hughes*, 640 F.2d at 1199, 208 USPQ at 791. To avoid invalidity under § 102(b), the Williams patent must necessarily have been entitled to the parent application's filing date, and, to be so entitled under 35 U.S.C. § 120, the parent must have been enabling under § 112 with respect to the invention set forth in the claims of the patent. The trial judge indicated that the invention referred to by the court in the government-cited language was not that set forth in the claims finally allowed. That language, moreover, may be viewed as premised on there having been sufficient enablement present in the parent application, the CIP having merely added an "amplification". In any event, we view the holding of the Court of Claims that the Williams patent is not invalid under § 102(b) as encompassing validity under § 112 and as the law of the case.

(B) *35 U.S.C. § 103*

A patent shall be presumed valid and the burden of persuasion is and remains always on the party asserting invalidity. 35 U.S.C. § 282. *Stevenson v. ITC*, 612 F.2d 546, 551, 204 USPQ 276, 281 (Cust. &

Pat.App.1979); *Solder Removal Co. v. ITC*, 582 F.2d 628, 632-33, 199 USPQ 129, 132-33 (Cust. & Pat.App.1978). The burden is less easily carried when the evidence relied upon consists only of the prior art considered by the examiner. *See Solder Removal*, 582 F.2d at 633, 199 USPQ at 133.

The government argues that because the subject matter of claims 1, 2, and 3 would have been obvious at the time the invention was made to a person having ordinary skill in the art, the Williams patent is invalid under 35 U.S.C. § 103. It relies heavily on the McLean patent considered by the examiner. The trial judge found, and the parties agree, that McLean is the most pertinent prior art. According to the government, McLean's space vehicle includes all elements recited in the claims except for a remote control capability, which it says would have been an obvious addition thereto.

As the trial judge noted, the argument fails because the premise is unsound, *i.e.*, "the device of McLean does not include all of the elements of the claims of Williams, except for remote control." Among the elements not disclosed by McLean is that of paragraph (e) of claim 1:

> e. means disposed on said body for providing an indication to a location external to said body of the instantaneous spin angle position of said body about said axis and the orientation of said axis with reference to a fixed external coordinate system;

The government cites the testimony of its expert, Peter G. Wilhelm, who, when asked to compare the language of (e) with McLean, said: "[N]either Williams nor McLean fits the classical definition of a

coordinate system, a fixed external coordinate system. But to the extent that the Williams apparatus can determine its position in . . . 'an external coordinate system', McLean does the equivalent. I see no difference in that." From that, the government says Williams and McLean each and to the same extent provide the indications recited in paragraph (e) of claim 1.

In *Hughes*, 640 F.2d at 1193, n. 1, 208 USPQ at 786, n. 1, the Court of Claims adopted most of the trial judge's findings. Adopted findings 33-62 (reproduced in *Hughes*, 640 F.2d at 1213-18, 208 USPQ at 803-07) establish that the Williams patent specification fully supports the claims, including the means recited in paragraph (e). Hence, Wilhelm's statement that Williams does not fit the claimed definition of a "fixed coordinate system" is erroneous.

Similarly, the government has not proven that McLean provides the recited indications, notwithstanding Wilhelm's indication to the contrary. The space vehicle of McLean maintains a collision course with a target, whereas the Williams satellite maintains its spin axis in an orientation parallel to the earth's spin axis while in synchronous orbit around the earth. The former, under internal control alone, automatically tracks a target, whereas the latter is controlled from the ground. Though both devices use a precessing jet on the periphery, pulsed synchronously with the spin cycle for changes in orientation, the differences in function lead to significant structural differences. Those differences are reflected in the claim language.

In arguing that McLean's space vehicle provides the indications recited in paragraph (e), the government assumes that the position of the vehicle's center

would be known for any given instant of time, and that McLean's target is a known star. Neither assumption is warranted by McLean's disclosure. If the assumptions be made, we nonetheless detect no error in the finding that McLean does not provide an indication of the orientation of his spin axis with reference to a fixed external coordinate system, when a spin axis is out of alignment with the target star. Unlike Williams, such indication is unnecessary for McLean to accomplish precession. As government witness Wilhelm stated: "[McLean] only really had the angle between his spin axis and the target. But in his case, that's all the information that he needs. He doesn't really have to work in an external coordinate system. He's only trying to aim a line, a target."

The government's argument to the contrary notwithstanding, Hughes did not misinform the Patent Office that the Williams V-beam sensor indicates spin axis orientation with reference to a fixed external coordinate system. As stated *supra*, findings made by the trial judge and adopted by the Court of Claims establish that Williams' disclosure of the V-beam sensor, coupled with the knowledge of one of ordinary skill in the art, supports the means recited in paragraph (e).

The government argues that the trial judge incorrectly interpreted McLean's teaching as restricted to a target-seeking vehicle in view of the McLean reissue patent (Re: 26,887, reissued May 19, 1970), broadly claiming a spin-stabilized vehicle under pulsed jet control. The argument is misplaced. McLean's *claims* added by reissue do broadly cover a spin-stabilized vehicle under pulsed jet control, but McLean's *disclosure* was not thereby changed. Whether Williams' claimed subject matter falls

within the scope of McLean's reissue claims is irrelevant to the inquiry here under 35 U.S.C. § 103. There is nothing inconsistent with issuance of broad claims to McLean and narrower claims to Williams. We agree with the trial judge that, as a prior art teaching applicable here, "the disclosure of the McLean reissue adds nothing of significance to what was disclosed in the original McLean patent."

Having concluded that the subject matter of claims 1, 2, and 3 would have been nonobvious in view of the most pertinent prior art, the trial judge found it unnecessary to consider the "secondary considerations" referred to in *Graham v. John Deere Co.*, 383 U.S. 1, 17-18, 86 S.Ct. 684, 693-94, 15 L.Ed.2d 545 (1966). Hughes points to the: (1) government's unsuccessful efforts to solve the attitude control problem, despite huge expenditures; (2) belief of experts that the problem could not be solved; (3) a long-felt need filled by the Williams invention; (4) commercial success; (5) government's protracted attempt to obtain title to the Williams patent; and (6) its admissions of non-obviousness during the title dispute. Those uncontested facts are additional evidence of nonobviousness, requiring no further discussion here.

Conclusion on Validity

We hold that the government has not proven the Williams patent invalid under 35 U.S.C. § 103.

II. Infringement

(A) *Literal Infringement*

In the "real-time" satellite disclosed by Williams, sun pulses (signals from the V-beam sun sensor) are transmitted to earth, enabling the ground crew to

simulate the rotation of the satellite and to calculate the satellite's spin rate, sun angle, and ISA position, *i.e.*, the measure of where the satellite is in its spin cycle at any instant of time. The sun pulses are known in "real time" and are used as reference points by the ground crew in transmitting firing signals to the jet, causing it to fire immediately and to produce precession.

In the accused S/E spacecraft, sun pulses are transmitted, but to a computer on board the spacecraft rather than to the ground. The computer calculates spin rate and transmits it to the ground. The computer also transmits sufficient information from which a ground crew can calculate the sun angle. With most S/E spacecraft, the ground crew does not know the spacecraft's ISA position. The ground crew does not need to know ISA position because the computer does and the ground crew knows the computer knows. With the IMP (H and J) spacecraft, sufficient information to determine ISA position is transmitted to ground, but is used for analyzing data from scientific experiments, not for attitude control.

The sun pulses present on S/E spacecraft provide reference points for firing the jet to effect precession just as they do in the Williams invention, but after, not upon, receipt from earth of spaced firing signals: (1) an "information" signal telling the on-board computer when in each revolution the jet should be fired and how many firings (one per revolution) should be made; and (2) an "execute" signal telling the computer when to begin firing.

The trial judge correctly found, and it is here undisputed, that there are only two distinctions in the structure of the claimed Williams satellite from that of the S/E spacecraft: (1) the SKYNET II, NATO II,

and DSCS II spacecraft do not include Williams' means for providing to the ground crew an indication of ISA position, having substituted computer-retention of that information; and (2) in all S/E systems, Wiiliams' means for receiving synchronized control signals for immediate execution are substituted for by an on-board computer for receiving control signals and storing them for later execution. Because the claims speak of means for "providing an indication" of ISA position "to a location external" to the satellite, and to means for receiving from the external location firing signals "synchronized with said indication", there can be no literal infringement. At trial, Hughes conceded the absence of literal infringement and predicated its case for infringement on the doctrine of equivalents.

(B) *Doctrine of Equivalents and Doctrine of File Wrapper Estoppel*

The doctrine of equivalents comes into play only when actual literal infringement is not present. Under the doctrine of equivalents, an accused product that does not literally infringe a structural claim may yet be found an infringement "if it performs substantially the same function in substantially the same way to obtain the same result" as the claimed product or process. *Graver Tank & Mfg. Co. v. Linde Air Products Co.*, 339 U.S. 605, 608, 70 S.Ct. 854, 856, 94 L.Ed. 1097 (1950) (quoting from *Sanitary Refrigerator Co. v. Winters*, 280 U.S. 30, 42, 50 S.Ct. 9, 13, 74 L.Ed. 147). The doctrine is judicially devised to do equity. "Courts have also recognized that to permit imitation of a patented invention which does not copy every literal detail would be to convert the protection of the patent grant into a hollow and useless thing,"

id. 339 U.S. at 607, 70 S.Ct. at 856, and again, "The essence of the doctrine is that one may not practice a fraud on a patent," *id.* at 608, 70 S.Ct. at 856.

As summarized by the Supreme Court:

> Equivalence, in the patent law, is not the prisoner of a formula and is not an absolute to be considered in a vacuum. It does not require complete identity for every purpose and in every respect. In determining equivalents, things equal to the same thing may not be equal to each other and, by the same token, things for most purposes different may sometimes be equivalents.

Id. at 609, 70 S.Ct. at 856-57.

Hughes, having the burden of proving infringement by a preponderance of the evidence, *Roberts Dairy Co. v. United States*, 530 F.2d 1342, 1357, 182 USPQ 218, 227 (Trial Div., Ct.Cl.1974), *aff'd* 198 USPQ 383 (Ct.Cl.1976), characterizes as "inconsequential" the differences in operation of the claimed invention and the accused S/E spacecraft. It asserts that the Williams satellite and S/E spacecraft are "obvious and exact equivalents". Hughes argues that: (1) though sun pulses are not sent to the ground by the SKYNET II, NATO II, or DSCS II spacecraft, they are retained in the on-board computer and used in the spacecraft for the same purpose as in Williams' "real-time" satellite, *i.e.*, as reference points to fire the precession jet; (2) respecting immediate and delayed firing, the Williams satellite and all S/E spacecraft require "synchronization of jet firing with spin position"; and (3) "[i]f there were doubt as to whether the S/E spacecraft are obvious and exact equivalents of Williams, the S/E spacecraft nevertheless fall

within the broad range of equivalents to which the pioneer Williams patent is entitled."

Addressing the last argument first, we agree with the trial judge that Williams' invention is not of such "pioneer" status as to entitle the invention to the very broad range of equivalents to which pioneer inventions are normally entitled. McLean, not Williams, was the first to disclose the basic operational concept in which a pulsed jet is used to precess the spin axis of a spin-stabilized body. That does not mean, as discussed below, that the Williams invention is entitled to no range of equivalents. Nor is the Williams invention entitled only to that very narrow range of equivalents applicable to improvement patents in a crowded art.

Having chosen specific words of limitation to avoid the McLean disclosure, Hughes is estopped by the prosecution history of the application ("file wrapper estoppel"), from obtaining a claim interpretation so broad as to encompass the McLean structure, or to encompass all structures in which a pulsed jet is used to precess the spin axis of a spin-stabilized body. The doctrine of prosecution history estoppel precludes a patent owner from obtaining a claim construction that would resurrect subject matter surrendered during prosecution of his patent application. The estoppel applies to claim amendments to overcome rejections based on prior art, *Dwyer v. United States*, 357 F.2d 978, 984, 149 USPQ 133, 138 (Ct.Cl.1966), and to arguments submitted to obtain the patent, *Coleco Industries, Inc. v. ITC*, 573 F.2d 1247, 1257, 197 USPQ 472, 480 (Cust. & Pat.App.1978). Williams did not, of course, surrender subject matter related to employment of an on-board computer to accomplish in a

differently timed manner what is accomplished by his disclosed structure.

An applicant for patent is required to disclose the best mode then known to him for practicing his invention. 35 U.S.C. § 112. He is not required to predict all future developments which enable the practice of his invention in substantially the same way.

The trial judge correctly stated that Hughes is estopped from asserting that the elements of its claims "are unnecessary to avoid the art". The relevant consideration, however, is not whether the claims avoid the art but whether the accused S/E spacecraft are equivalents of the inventions set forth in the claims interpreted in light of the prior art. The government is not claiming that its S/E spacecraft are built and operated in accord with the prior art, or that it is merely following the teachings of McLean. If it had followed those teachings in constructing its S/E spacecraft, there is no question that the range of equivalents to which Williams' claimed invention is entitled could not be broad enough to encompass such spacecraft.

Some courts have expressed the view that virtually any amendment of the claims creates a "file wrapper estoppel" effective to bar all resort to the doctrine of equivalents, and to confine patentee "strictly to the letter of the limited claims granted," *Nationwide Chemical Corp. v. Wright*, 584 F.2d 714, 718-19 (5th Cir.1978); *Ekco Products Co. v. Chicago Metallic Manufacturing Co.*, 347 F.2d 453, 455 (7th Cir.1965). We, as has the Supreme Court, reject that view as a wooden application of estoppel, negating entirely the doctrine of equivalents and limiting determination of the infringement issue to consideration of *literal*

infringement alone. That view, as above indicated, fails to recognize that the doctrine of equivalents is unnecessary when literal infringement is present and is contrary to the guidance provided by the Supreme Court in *Graver*, supra.

Amendment of claims is a common practice in prosecution of patent applications. No reason or warrant exists for limiting application of the doctrine of equivalents to those comparatively few claims allowed exactly as originally filed and never amended. Amendments may be of different types and may serve different functions. Depending on the nature and purpose of an amendment, it may have a limiting effect within a spectrum ranging from great to small to zero. The effect may or may not be fatal to application of a range of equivalents broad enough to encompass a particular accused product. It is not fatal to application of the doctrine itself.

We adhere to the view expressed by our predecessor court in *Autogiro Co. of America v. United States*, 384 F.2d 391, 155 USPQ 697 (Ct.Cl.1967), and in *Garrett Corp. v. United States*, 422 F.2d 874, 164 USPQ 521 (Ct.Cl.), *cert. denied*, 400 U.S. 951, 91 S.Ct. 242, 27 L.Ed.2d 257 (1970). Discussing the relationship between the doctrines in *Autogiro*, the Court of Claims said:

> The doctrine of equivalence is subservient to file wrapper estoppel. It may not include within its range anything that would vitiate limitations expressed before the Patent Office. Thus a patent that has been severely limited to avoid the prior art will only have a small range between it

> and the point beyond which it violates file wrapper estoppel [Citations omitted].

384 F.2d at 400-01; 155 USPQ at 705.

Referring to the April 29, 1966 amendment described above, Hughes says: "All that Williams surrendered in order to avoid the prior art cited by the examiner were any claims that could be construed as applying to an automatic attitude control system not controllable from earth . . . [the] amendment did nothing but more accurately claim ground controllability as the point of novelty." We disagree. In that amendment, Williams did not submit claims broadly covering all ground controllable spacecraft, as he might have. Had he done so, and had such claims been allowed, literal infringement would have been present here. At the same time, Williams' amendment of the claims did not relate to any disclosure, in the prior art or elsewhere, in which the ISA position was stored in a computer along with command signals for later execution. Though we cannot agree that Williams' amendment left room for encompassing all ground-controlled spacecraft, it remains true that the operation of the Williams and S/E spacecraft involve control input from a ground crew, and McLean does not. That is an important consideration in applying the doctrine of equivalents. It does not *alone* establish infringement under that doctrine.

Application of the Doctrine of Equivalents

The issue, as above indicated, is whether the accused S/E spacecraft infringe the claims under the doctrine of equivalents. That question turns on whether the S/E spacecraft employ substantially the same means which "perform substantially the same function" as that performed by the claimed invention,

and do so "in substantially the same way" the claimed invention does, and "obtain the same result" as that obtained by the claimed invention.

In his opinion, exhaustive in respect of other issues, the trial judge treated the subject of equivalency in a single conclusory paragraph:

> There is no obvious or exact equivalent of plaintiff's means for providing an indication of the ISA to an external location in either of the SKYNET II, NATO II or DSCS II systems. Nor is there an obvious or exact equivalent of the means for pulsing the precession jet within a fixed time period after the receipt of a control signal in any of the accused store and execute systems.

The trial judge declined to supply reasoning in support of that conclusion and did not apply the "substantially the same function, in substantially the same way, to obtain the same result" guidance set forth in *Graver*, *supra*. He also declined, as have the parties here, the opportunity to define "obvious or exact equivalent". That phrase is not defined, moreover, in the case on which he relied, *Eastern Rotorcraft Corp. v. United States*, 397 F.2d 978, 982, 154 USPQ 43, 46 (Trial Div., Ct.Cl.1967), *aff'd* 158 USPQ 294 (Ct.Cl.1968), or in the case cited therein, *Southern Textile Machinery Co. v. United Hosiery Mills Corp.*, 33 F.2d 862, 866, 2 USPQ 183, 186 (6th Cir.1929). Neither the trial judge nor the government, for example, has explained why employment of the now-well-known store and execute capabilities of a computer was not an employment of substantially the same means or an "obvious" equivalent, or why the performance thereby of the functions of the

Williams' claimed elements did not render the S/E spacecraft "exact" equivalents.

However the phrase "obvious and exact equivalents" may be defined, it was effectively and improperly applied here as a substitute for literal infringement, the absence of which was conceded. The failure to apply the doctrine of equivalents to the claimed invention as a whole, and the accompanying demand for "obvious and exact" equivalents of two elements the presence of which would have effectively produced literal infringement, was error.

In *Eastern Rotorcraft*, the Court of Claims afforded the patentee a limited application of the doctrine of equivalents, concluding that the range of equivalents of the claimed invention there encompassed the accused device. We hold that the trial judge erred as a matter of law in not so interpreting the scope of Williams' claims 1, 2, and 3 in their entirety, and in applying an appropriate range of equivalents to the entirety of the accused S/E spacecraft.

There are striking overall similarities between Williams' claimed satellite and the S/E spacecraft: (1) each is spin-stabilized; (2) each contains a jet on the periphery, connected by a valve to a tank containing fluid for expulsion substantially parallel to the spin axis; (3) each employs sun sensors to sense ISA position; (4) each requires knowledge of orientation relative to a fixed external coordinate system; (5) each contains radio equipment for communicating with the ground; (6) each transmits spin rate and sun angle information to a ground crew; and (7) in each, jet firing is synchronized with ISA position to effect controlled precession and thus to achieve a desired orientation. Only elements (1) and (2) are found in McLean. Clearly, the S/E spacecraft are much closer

to Williams' satellite than they are to McLean's space vehicle. It is clear also that, in constructing its S/E spacecraft, the government followed the teachings of Williams much more than it did those of McLean. In following Williams' teachings, the government merely employed a modern day computer to do indirectly what Williams taught it to do directly.

The dispute as presented centers on what appears in paragraphs (e), (f), and (g), of representative claim 1:

> e. means disposed on said body for providing an indication to a location external to said body of the instantaneous spin angle position of said body about said axis and the orientation of said axis with reference to a fixed external coordinate system;
>
> f. and means disposed on said body for receiving from said location control signals synchronized with said indication;
>
> g. said valve being coupled to said last-named means and responsive to said control signals for applying fluid to said fluid expulsion means in synchronism therewith for precessing said body to orient said axis in a predetermined desired relationship with said fixed external coordinate system.

Paragraph (e) "providing an indication"

Based on the testimony of its expert, Arthur E. Bryson, Jr., Hughes argues that the S/E spacecraft, with the ISA position indication retained on-board, are equivalents of Williams' claimed satellite, with the ISA position indication sent to ground, performance of the function involving the ISA position being

substantially the same in each. We agree. Once an on-board computer became available, as Bryson said, "any intelligent engineer designing this [S/E] system would say 'Look, I don't need to send the value of that ISA position to the ground, it's right there in the spacecraft. I'll just key my firing signal to that on board the spacecraft'."

The S/E spacecraft are identical with the Williams satellite, except for the employment of sophisticated, post-Williams equipment (computers) to achieve attitude control in the basic manner taught by Williams. Advanced computers and digital communications techniques developed since Williams permit doing on-board a part of what Williams taught as done on the ground. As one of our predecessor courts, the Court of Claims, has thrice made clear, that partial variation in technique, an embellishment made possible by post-Williams technology, does not allow the accused spacecraft to escape the "web of infringement". *Bendix Corp. v. United States*, 600 F.2d 1364, 1382, 204 USPQ 617, 631 (Ct.Cl.1979); *see Decca Ltd. v. United States*, 544 F.2d 1070, 1080-81, 191 USPQ 439, 447-48 (Ct.Cl.1976); *Eastern Rotorcraft Corp. v. United States*, 397 F.2d at 981, 154 USPQ at 45.

That an appropriate range of equivalents of the claims extends beyond devices that send the ISA position indication to ground is consistent with Williams' patent specification:

> As an example of one means of controlling the starting time and duration of pulses to the jet control valves . . . in such a way as to result in thrust during the correct portion of each spin revolution, cam-controlled contacts or switches may be used.

In the operation of the S/E spacecraft, the information that is transmitted to the ground crew, to enable them to determine and provide thrust during "the correct portion of each spin revolution", is the modern-day equivalent of sending the ISA position indication to the ground for that same purpose in Williams. Put another way, retention of the ISA position in an on-board computer, while transmitting sufficient information to enable the ground crew to use that computer-retained information to control the satellite, is the modern-day equivalent of providing an indication of ISA to ground as taught by Williams.

The government asserts only that its S/E spacecraft do not send an indication of the ISA position to the ground. That argument is clearly effective against an allegation of literal infringement, for if the S/E spacecraft *did* send an ISA position to the ground, literal infringement of that element of the claims would be clear. Williams controls his satellite, and the government controls its S/E spacecraft, from the ground. That Williams does so in "real time" and the government does so in a delayed reaction made possible by the advent of computers does not establish that the S/E spacecraft do not perform the same function in substantially the same way to obtain the same result.

Paragraphs (f) & (g) "direct" vs. "indirect" firing

The distinction emphasized by the government between "direct" firing and its own "indirect" firing, phrased also as a distinction between "external" and "internal" synchronization of command signals with ISA position, and as a distinction between firing in "fixed" time and in "computer-set" time, rests on the government's use of modern memory circuits

on-board S/E spacecraft to store commands for later use. As above indicated, mere substitution of an embellishment made possible by post-Williams technology does not avoid infringement. *See Bendix Corp., Decca Ltd.*, and *Eastern Rotorcraft, supra.* Applying the guidance of those cases, along with that in *Graver, supra*, the range of equivalents of the present claims reaches the S/E spacecraft, wherein sun pulses, though retained on-board, are derived and used in the same way as in Williams to perform the same function, jet firing, which, though "indirect", is synchronized with ISA position precisely as taught by Williams.

The S/E spacecraft and the Williams claimed satellite each have on-board means for transmitting to ground the sun angle and spin rate. In each, the ground crew determines: (1) present orientation; (2) desired orientation; and (3) where in the spin cycle and how many times the jet must be pulsed to change (1) to (2). Each system, furthermore, provides for receipt of command signals to cause firing of the precession jet. The S/E spacecraft uses sun pulses retained on-board as reference points to fire the jet. Williams uses sun pulses sent to ground as reference points to fire the jet. The difference between operation by retention and operation by sending is achieved by relocating the function, making no change in the function performed, or in the basic manner of operation, or in the result obtained.

Conclusion on Equivalents

The S/E spacecraft and the claimed Williams satellite reflect the precise circumstance envisaged in *Graver, supra*, for they perform the same function (receipt of and response to command signals from an

external location to accomplish precession), in substantially the same way (jet firings synchronized, albeit later and internally, with ISA position) to obtain substantially the same result (controlled precession of spin axis in a predetermined direction to orient a hovering satellite). At the same time, neither resembles as closely the self-guiding space vehicle of McLean or its purely automatic operation.

Accordingly, we hold that Hughes has proven that the government's S/E spacecraft infringe Williams' claims 1, 2, and 3 under the doctrine of equivalents.

DECISION

The holding that the Williams patent is valid is affirmed. The finding that the claims are not infringed by certain of the accused S/E spacecraft is reversed. The case is remanded for determination of the quantum of recovery due Hughes for infringement by the accused SKYNET II, NATO II, DSCS II, IMP (H and J), SOLRAD (9 and 10), and PIONEER (10 and 11) spacecraft.

AFFIRMED-IN-PART, REVERSED-IN-PART, AND REMANDED.

DAVIS, Circuit Judge, concurring in part and dissenting in part.

I join the court's opinion except for the discussion of, and decision on, infringement by the S/E spacecraft through the doctrine of equivalents. On the latter issue, on which I dissent, I agree with Judge Colaianni that the S/E satellites do not infringe the Williams patent. I would therefore affirm all of his decision.

My difference with the majority is that I would hold the doctrine of equivalents inapplicable to the S/E spacecraft involved here because, to find equivalence

as the majority does, that doctrine has to be stretched far too broadly for the Williams patent.

1. The status and history of the patent is very important. I agree with the majority that Williams is not a pioneer patent; accordingly, it is not entitled to the broad range of equivalents allowable for pioneer inventions. In addition, the prosecution history shows that, after the citation of McLean, the Williams inventors cancelled several of their original, broad claims and substituted new claims (now claims 1-3) containing new limiting elements directly relevant to the charge of infringement by the S/E satellites: (1) means for providing an indication of ISA to an external location; and (2) means for applying fluid to fluid expulsion means within a fixed time period after the receipt of a control signal from the external location. The accused S/E spacecraft do not contain those elements which were expressly included to overcome prior art.[5] As the majority says, these new claims show that Williams did not submit claims broadly covering all ground controllable spacecraft. An infringing article must embody the two elements I have mentioned, either literally or through an appropriate equivalent. Those elements show the invention which was patented in this Williams patent.

2. In the light of Williams' non-pioneer status and of this prosecution history I cannot accede to the majority's entire dispensation (with respect to three of the S/E spacecraft) of the specific element of "means * * * providing an indication" to a specific external location of the ISA. As the trial judge put it,

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[5] SKYNET II, NATO II and DSCS II do not have either means; none of the accused S/E spacecraft (including the three just mentioned plus IMP (H and J)) has the second means.

this part of the claims (and the relevant claims as a whole) expressly call for a structure on the spinning body which is limited "to an altitude [*sic*] control system wherein a ground controller is needed to determine the ISA * * * *."

It is clear, however, that these three accused satellites—SKYNET II, NATO II and DSCS II—do not provide any indication whatever of ISA to the earth (or any other external source). Moreover, the ground personnel have absolutely no need to know the ISA position, do not know it, and cannot determine it. The calculations involving ISA are wholly done by an on-board computer and are available only there. To find, as the majority does, in this self-contained on-board computer an equivalent of the specific requirement for providing an indication of ISA to the ground (so that the ground can take account of ISA) is simply to obliterate and disregard this element of the claims. These accused structures may possibly obtain "the same result" as Williams but they do not perform "the same function" in "the same way" either literally or substantially. Whether or not this on-board device for calculation would be unobvious—and there is no finding and (to my mind) no showing that it would have been obvious—its substitution was not a proper equivalent for infringement of this non-pioneer patent because the wholly on-board computer device operated in a different way to perform the different function of a significant calculation unrelated to ground personnel.[6] Unlike the Court of

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[6] The majority quotes Hughes' expert as testifying that it would have been obvious to place the calculating device on the spacecraft but the Government's witnesses testified that this device was not an equivalent.

Claims decisions cited in the court's opinion this is not the case of a "sophisticated" technique of performing the same function in the same way. It is a "sophisticated" method of performing a different function in a different way. Even if the standard of "obvious and exact equivalents" (*Eastern Rotorcraft Corp. v. United States*, 397 F.2d 978, 982, 154 USPQ 43, 46, 158 USPQ 294 (Ct.Cl.1968)) is considered as too narrow, the accused devices here are definitely outside the equivalence principle of *Graver Tank & Mfg. Co. v. Linde Air Products Co.*, 339 U.S. 605, 608, 70 S.Ct. 854, 856, 94 L.Ed. 1097 (1950).

3. The same is true of the elements specifying the method for controlling the precession jet. In this regard, Williams, again as Judge Colaianni points out, limits its claims so as to require a ground controller, not only to determine the ISA, but also to use the ISA to pulse the precession jet during the desired portion of the spin cycle. As to the latter, the claims in suit also require means for pulsing the precession jet within a fixed time period after the receipt of the control signal. This does not occur in any of the accused structures, nor does the ground location use ISA to determine the execute command.[7]

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[7] The trial judge put it: "[Hughes] admits that in Williams the jet is activated directly upon receipt of the control signal while in the store and execute systems the command signal is first stored and verified. The later execute signal in the store and execute systems sets the original command into action but there is no fixed time interval between the receipt of the execute signal and the firing of the precession jet. No command signal is synchronized with the ISA. There is no structure on the store and execute spacecraft which acts to pulse the precession jet within a fixed time period after the receipt of a control signal." In Williams, on the other hand, "[in] order to

As with the other Williams element ("providing an indication" of ISA) discussed *supra*, the elements pertaining to "firing" or "execution" cannot properly be deemed equivalents of the pertinent Williams elements. The gist of Williams was that this function was to be performed primarily by the ground location acting externally to the spacecraft on the basis of an indication of ISA transmitted to that location.[8] The S/E spacecraft, on the contrary, utilizes an on-board computer and command storage means for receiving and storing a different type of control signal (as well as also using on-board ISA data); ground personnel have only a limited, secondary role and do not take account of ISA. Moreover, in Williams there must be a fixed time period between the receipt by the spacecraft of a control signal and the activation of the precession jet. In the S/E satellites, in contrast, neither the ground nor the execute signal operates to activate the precession jet within a fixed time period (instead, that period varies). The sum of it is that the S/E structures perform a "different function" in a "different way" from those claimed by Williams—and are therefore not within the *Graver* principle.

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permit the ground control to pulse the precession jet during the proper portion of the open cycle, there must be a known fixed time period between the receipt of a control signal and the activation of the precession jet."

[8] I have already indicated, *supra*, that in my view the prosecution history reflects strong emphasis by the applicants on control through an external location. The trial judge has also taken that position.

4. The result, as I see it, is that the doctrine of equivalents cannot be employed in this case without taking an impermissible quantum leap outside the perimeters of that principle as it should be applied to the Williams patent.

APPENDIX D

UNITED STATES COURT OF CLAIMS

TRIAL DIVISION

No. 426-73

HUGHES AIRCRAFT COMPANY

v.

THE UNITED STATES

(Filed Sept. 1, 1982)

OPINION*

COLAIANNI, *Trial Judge*: The Hughes Aircraft Company seeks reasonable and entire compensation, pursuant to 28 U.S.C. § 1498, for the unlicensed use of United States Patent No. 3,758,051 (hereinafter "the Williams patent").[1] In an earlier recommended decision and conclusion of law (*Hughes Aircraft Co.* v. *United States*, 205 USPQ 381 (1979)), I found that the Williams patent was invalid under 35 U.S.C. § 102(b).

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* The trial judge's recommended decision and conclusion of law are submitted in accordance with Rule 134(h).

[1] The patent in suit, United States Patent No. 3,758,051 for velocity control and orientation of a spin-stabilized body, was issued to Donald D. Williams on September 11, 1973, on an application filed August 21, 1964. This patent is a continuation-in-part of Serial No. 22,733, filed April 18, 1960, now abandoned.

On appeal, this court, in Hughes *Aircraft Co.* v. *United States*, 226 Ct.Cl. __, 640 F.2d 1193, 208 USPQ 785 (1980), found that "the Williams patent is not invalid under 35 U.S.C. § 102(b)," and remanded the case to me for "a recommended decision and findings on the other issues presented." *Id.* at 1199, 208 USPQ at 791.

The Williams patent relates to a general attitude control system (ACS) for spacecraft first used in the Hughes manufactured Syncom II and Syncom III satellites, the world's first synchronous communications satellites. This invention was allegedly used for and/or manufactured by or for the United States in the Skynet II, NATO II, DSCS II, IMP (H and J), Solrad (9 and 10), and Pioneer (10 and 11) systems. The Government denies infringement, and disputes the validity and enforceability of the Williams patent. For reasons discussed below, I find that the Williams patent is valid and enforceable and that of the accused systems the Solrad (9 and 10) and Pioneer (10 and 11) systems infringe that patent.

The Communications Satellite Design Problem

An early goal of the space program was the development of a synchronous communications satellite.[2] A network of such satellites was contemplated to enable worldwide radio coverage of events.

In the late 1950's and early 1960's the launch vehicles used for propelling rockets were of limited

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[2] A radio communication satellite must be placed in a west-to-east circular orbit in the earth's equatorial plane, and have a period of 24 hours. In order to "hover" above a single point on earth, the satellite must be placed in an orbit having a 22,750-nautical-mi. radius from the center of the earth and travel around the orbit at a linear velocity of 10,090-ft. per second.

capacity and capable of lifting only the smallest of payloads. Accordingly, designers in the early days of satellites were necessarily obsessed with weight considerations. To economize on power and weight, the communications satellites were equipped with directional antennas. Ironically, elaborate pointing systems seemed necessary to keep the earth within the narrow antenna beams. These systems, which employed three sets of gyroscopes and rocket motors (three-axis ACS), proved too heavy to be lifted into synchronous orbit by the available launch vehicles.

Developments at Hughes

The use of jet vanes, spin nozzles, or spin rockets, to rotate various stages of the rocket used to convey a satellite into orbit about its longitudinal axis for stability, was well known. As a result, a satellite will have a spin imparted to it as it assumes its spacial orbit. Hughes' engineers, Harold A. Rosen and Donald D. Williams, realized that the continual correction of a satellite's attitude was unnecessary, since the orientation of a spinning satellite with respect to a fixed external coordinate system is not affected by its orbital motion.

Despite the advantages of spin stabilization, Hughes faced numerous formidable hurdles that had to be overcome in order to ensure acceptable communication between the high altitude orbital position of the satellite and earth. In the first place, the satellite transmitter required a certain degree of antenna directivity. A "pancake" beam antenna was selected as the simplest technique compatible with spin stabilization. This type of antenna radiates a beam which is at maximum intensity along a plane perpendicular to the axis of the antenna. For this reason, the

pancake beam antenna is useful only when the earth is in the plane of the pancake beam. Thus, to obtain continuous maximum antenna gain, the spin axis of the satellite, with which the axis of the antenna is coincident, must be normal to the plane of the orbit. Moreover, the array of glass-coated solar cells which covered the exterior of the satellite and acted as the satellite's power supply required as much exposure to the sun as possible.

For ballistic reasons, a communications satellite will be injected into orbit with its spin axis lying in its orbital plane. Thus, to maximize gain from the pancake beam antenna and to optimize performance from the solar cell power supply, it is necessary to reorient the spin axis of the satellite through 90 degrees. For this reason, Messrs. Rosen and Williams suggested that the satellite be equipped with a set of spin jets, which, when pulsed, would cause the satellite to spin about the antenna axis. Reorientation would consist of stopping the old spin and initiating the new.

The Rosen-Williams ACS was described in a patent application filed December 30, 1959, and issued as patent No. 3,396,920 on August 13, 1968. The inventors recognized that theirs was not a complete solution to the attitude control problem, since, among other things, solar radiation and magnetic fields would gradually disturb the orientation of the satellite, and their ACS reorientation capabilities were limited.

Subsequent work by Mr. Williams led to the realization that a single jet, mounted parallel to the antenna axis, but offset therefrom, could be used to

precess[3] a satellite into a desired orientation. The Williams system achieved greatly improved results over the Rosen-Williams ACS.

The first written description of the invention appeared in a January 1960 confidential report on the status of Hughes Commercial Communication Satellite (Comsat). This report disclosed a spin stabilized satellite equipped with a directional antenna, a V-beam sun sensor and a ground commandable precessing jet.

The Original Williams Application

On April 18, 1960, Williams filed the parent application on the invention in suit. This application contained essentially the same Figs. 1-11, and their accompanying descriptions as are found in the patent in suit. It did not, however, contain either Fig. 12, nor the accompanying description.

The 1960 application described a method and apparatus for controlling the orientation of the spin axis of a spin stabilized space vehicle. As an exemplary embodiment of the invention, the specification and drawings presented an earth-orbiting, spin-stabilized satellite. The satellite was equipped with a pancake beam directional antenna, a V-beam sensor, a radio transmitter for transmitting information detected by the sensor to the earth, an axial fluid jet offset from the spin axis for correcting the attitude, and a radio receiver hooked up to activate the fluid jet when the proper signal is received. No specific earth-based remote control device was disclosed. However, the

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[3] Precession is the change in the orientation, with respect to an external reference frame, of the spin axis of a spinning body.

1960 application indicated that any of several remote control systems that were well known in the art could be used.

Obviously, before any correction in attitude takes place, it is necessary to find the present orientation of the satellite. Having determined its present orientation and knowing the desired orientation, the required amount of attitude correction can be established. Attitude or orientation sensing is not only needed to establish the amount of correction required, but also to repeatedly pulse the attitude correction jet at the proper phase in the spin cycle to achieve the desired correction in attitude. The 1960 application provided for both solar and radio frequency sensing of attitude.

A V-beam sun sensor, which was well known in the art at the time of the Williams invention, was used as the solar orientation sensing device. It measured the sun angle, the angle between the satellite's spin axis and the satellite's sun vector (the sun line), and the spin angle position, the degree of rotation of the jet past the sun line. This information is transmitted to a ground-based control station by means of a directional antenna and provides two of the needed three attitude angles required to establish the geometric position of the satellite in space.

The 1960 application, in addition, indicated that the directional antenna could also be used as an orientation means.

> As to the disclosed means for sensing the orientation of the satellite, * * * it will be understood that other means may be provided. For example, asymmetry may be deliberately intro-

duced into the antenna radiation pattern of the satellite.[4]

Once the desired precession maneuver is calculated, the necessary control signals are sent up to the satellite. These control signals are synchronized with the spin cycle of the satellite, and, as a result, the precessing jet is activated at the proper phase of the spin cycle. The specification makes clear that the spin angle indication provided by the solar sensor is used as a time reference for these control signals.

In operation, precession is accomplished, as explained in the 1960 application, by the reactive force produced by the jet of nitrogen gas which is expelled by the attitude control nozzle. (*See* col. 8, lines 17-41, of the Williams patent.) A thrust is applied parallel to the spin axis and near the periphery of the satellite. In this manner, a net torque is produced around an axis perpendicular to the spin axis of the satellite. By periodic pulsing of the attitude control jet for a predetermined portion of a spin cycle of the satellite, with a synchronized control signal, a torque is applied to precess the spin axis in the direction of the desired correction. Pulsing of the control jet is continued in subsequent spin cycles until the spin axis of the satellite is precessed through 90 degrees and it is parallel to the earth's axis. The spin axis of the satellite can be corrected immediately after the launch operation or at any other time in order to maintain the spin axis parallel to the earth's axis.

The 1960 application presented nine claims to the Patent and Trademark Office for consideration by the examiner. As an aid to understanding the examiner's

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[4] Col. 11, lines 9-15, of the Williams patent.

position in later actions, the language of original claim 2 is instructive. Claim 2 claimed a body with a spin axis, a source of pressurized gas, a jet disposed on the body parallel to and spaced from the spin axis, a controllable valve connecting the gas to the jet, and "control means coupled to said valve for actuating said valve in pulses synchronized with the spin of said body." Comparing this claim language with the example disclosed by the application, it is clear that the "control means" necessarily encompasses the remote control system, including some sort of ground controller. This is because, as disclosed, the remote control system is an indispensable link in the loop providing the synchronization between the sensing of the spin angle position of the body and the pulsing of the jet valve needed for controlled precession. Since the examiner at the Patent and Trademark Office before whom the application was pending made no objection to claim 2 under the first paragraph of 35 U.S.C. § 112,[5] it must be assumed he felt that the broad recitation of ground controller in that claim, as well as all of its other elements, was supported by the original disclosure.

Following the first two office actions by the examiner, plaintiff, on January 3, 1963, cancelled claim 2 and filed new claims 15-19 in its pending

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[5] 35 U.S.C. s 112, first paragraph:

"The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention."

application. These claims, in applicant's own words, "are drawn to applicant's apparatus for changing the attitude and translational velocity of a spinstabilized body * * *." Applicant argued that the following language of claim 15 was patentably distinct over the art of record:

> [C]ontrol means coupled to said valve for actuating said valve in a series of pulses occurring once per each revolution of said body about said axis and whose starting and stopping times are determined by the instantaneous angle of rotation of said body about said axis with respect to a reference point in space to produce a series of incremental forces that result in a net force on said body in a predetermined direction.

Applicant also maintained that claim 16 was patentable over the cited prior art, since it called for:

> [M]eans associated with said body for expelling fluid more than once from a particular location thereon to exert a series of incremental forces on said body during several revolutions of said body about said axis, said means controlling the duration of each expulsion of fluid to be short compared to the time of one revolution of said body about said axis, said means controlling the time of occurrence of each expulsion of fluid to be at a predetermined part of the cycle of revolution of said body about said axis.

The plaintiff made similar arguments in connection with claims 17-19.

In the next and final office action of December 24, 1963, the examiner rejected these claims as being drawn to an inadequate disclosure. He stated:

> Claims 15-19, newly presented, are rejected as drawn to an inadequate disclosure. There is nothing in the original disclosure to indicate how the starting and stopping time or duration of the pulses is determined by the instantaneous angle of revolution of the body with respect to a reference point. The signals from 71 and 73 are sent by 90 and 50 to earth or another planet but there is no disclosure as to how such information is converted and used to send back to 90 for control of 93.

The examiner here is referring to the requirements of the first paragraph of 35 U.S.C. § 112.[6]

In response to this rejection, Hughes on June 22, 1964, filed an amendment after final rejection, wherein it requested that the Patent and Trademark Office permit it to amend the specification and claims 15-19 of its pending application. The examiner declined to enter the amendment, maintaining that it would introduce new matter into the case, since there was no support for the changes requested in the original specification, and that the proposed amendment would not, in any event, remedy the inadequacy of the disclosure. On June 23, 1964, Hughes filed a notice of appeal of the examiner's decision, but the appeal was never perfected.

The Continuation-in-Part Application

On August 21, 1964, Hughes filed a continuation-in-part (CIP) application based upon the original application of April 18, 1960. It is this CIP application[7]

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[6] *Id.*

[7] A CIP application usually contains additional material not found in the original application. If the CIP complies with 35 U.S.C. § 120, the originally disclosed subject matter is entitled

from which the patent in suit ultimately matured. Plaintiff then permitted the original parent application to go abandoned.

Plaintiff's CIP application retained the disclosure of the 1960 parent application described above and added some material. This material consisted of Fig. 12 and the portion of the specification relating thereto. Figure 12 shows a ground-based analog controller for synchronizing the control signals it generates with the spin of the satellite. A rotating drum, formed with a raised cam section, is the analog element disclosed. The spin angle information provided by the sun sensor is used to match the drum's phase of rotation to the rate of spin of the satellite. A fixed switch is positioned such that contact between the leading edge of the cam and the fixed switch coincides with the ground reception of the solar sensor pulse. The speed of the drum is adjusted until such a coincidence occurs. Upon achieving this, the drum has been synchronized with the spin of the orbiting satellite. In addition, a movable switch is positioned such that its closure transmits a control pulse to the satellite for actuation of the attitude adjustment valve.

This analog controller had previously been described in a paper delivered by a Hughes employee (Roger W. Cole) to the 18th Annual Meeting of the Institute of Navigation, June 18-20, 1962.

When originally filed, plaintiff's CIP application presented claims 1-18 for the examiner's consideration. Claims 4-7, 10 and 13 each recited "control means" using language very similar to the language

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to the filing date of the original application. However, any new matter added in the CIP is entitled to only the filing date of the CIP application.

discussed previously in connection with claims 15-19 of the 1960 application. In the first office action following plaintiff's filing of the CIP, the examiner held that claims 4-7, 10 and 13 were not supported by the disclosure of the parent (1960) application. The examiner then rejected these claims under 35 U.S.C. § 102(b) because the invention was identically disclosed in a paper published more than one year prior to the filing date of the CIP application by one of plaintiff's own employees, Roger W. Cole. The examiner specifically stated that:

> The subject matter of applicant's Fig. 12, relating to the means for controlling the starting and stopping times, and duration, of control valve actuation, so as to be in synchronism with body rotation, as determined by a function of the instantaneous angle of rotation of the body with respect to a reference in space, is entitled to the filing date of the instant application only. Thus, Cole's disclosure operates as a statutory bar against such matter, as claimed, under 35 U.S.C. 102(b).

The examiner here was objecting to the details of the control means recited in claims 4-7, 10 and 13 which he felt were not disclosed in the parent application. The examiner was not making a finding that the disclosure of the original application would not enable one skilled in the art to use the satellite. Had he made such a finding, he would have rejected all the claims under 35 U.S.C. § 112, first paragraph, not just those reciting the objectionable details.

In response, plaintiff, by its July 21, 1965, amendment, cancelled claims 4, 6 and 7, and amended the "control means" portion of each of claims 5, 10 and 13 such that the recitation closely tracked that of origi-

nally filed claims 2 (of the 1960 parent application) discussed previously. With regard to the rejections based on Mr. Cole's article, plaintiff stated:

> Claims 5, 10, and 13 were rejected as being fully met by the Navigation article by Cole under 35 U.S.C. 102. Claims 5, 10 and 13 have been amended to delete reference to the control of starting and stopping times and the duration of valve actuation. Accordingly, Cole's disclosure can not now be considered to operate as a statutory bar against claims 5, 10 and 13.

In the next office action the examiner, apparently in agreement with plaintiff, dropped the rejection based on the Cole reference. However, all of the pending claims were finally rejected as being unpatentable over the newly cited patent to McLean (U.S. Patent No. 3,216,674) in view of a previously cited patent to Geyling (U.S. Patent No. 2,991,027) under 35 U.S.C. §-103. In response, Hughes cancelled the rejected claims and inserted, by amendment, new claims 19-21 into the application. These claims were allowed by the examiner without comment and became claims 1-3 of the patent in suit. It must be assumed then, that the examiner felt these claims too were entitled to the April 18, 1960, filing date of the original application.

The CIP application issued as the William patent (the patent in suit), consisting of the three claims (1-3) allowed, as described above. Claim 1, the broadest claim in suit, reads as follows:

1. Apparatus comprising:

    a. a body adapted to spin about an axis;

b. fluid supply means associated with said body;

c. a valve connected to said fluid supply means;

d. fluid expulsion means disposed on said body and coupled with said valve and oriented to expel said fluid substantially along a line parallel to said axis and separated therefrom;

e. means disposed on said body for providing an indication to a location external to said body of the instantaneous spin angle position of said body about said axis and the orientation of said axis with reference to a fixed external coordinate system;

f. and means disposed on said body for receiving from said location control signals synchronized with said indication;

g. said valve being coupled to said last-named means and responsive to said control signals for applying fluid to said fluid expulsion means in synchronism therewith for precessing said body to orient said axis in a predetermined desired relationship with said fixed external coordinate systems.

Claim 2 differs from claim 1 in that the clause (e) "means" of claim 1 is recited in clause (f) of claim 2 as "wide angle means." In claim 3, element (e) of claim 1 is further limited to "wide angle optical means." The other limitations recited in claims 2 and 3 are not material to this litigation.

The court in *Hughes Aircraft Co.* v. *United States*, 226 Ct.Cl. __, 640 F.2d 1193, 208 USPQ 785 (1980), found that none of claims 1-3 include a ground controller as an element.

Scope of Remand

As mentioned previously, the court on review concluded that the patent in suit was not invalid under 35 U.S.C. § 102(b), and remanded the case to me for a recommended decision on the "other issues." *Id.* at __, 640 F.2d at 1199, 208 USPQ at 791. Defendant argues that although the court's decision clearly precludes one path by which 35 U.S.C. § 102(b) can be found to invalidate the patent, other paths have been left open and must be dealt with on remand.

For the reasons discussed hereinafter, it is concluded that the court's decision has precluded any further consideration of 35 U.S.C. § 102(b) issues.

In order to understand the questions involved, it is useful to recall that my original decision was reached in three steps. First, I found that the ground control device shown in Fig. 12 of the patent was a claimed element of all three claims. Next, I found that these claims were only entitled to the filing date of the continuation-in-part application (which matured into the patent in suit). This was because the parent application failed to provide sufficient support in accordance with 35 U.S.C. §§ 120[8] and 112, first para-

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[8] 35 U.S.C. § 120 provides:

"An application for patent for an invention disclosed in the manner provided by the first paragraph of section 112 of this title in an application previously filed in the United States by the same inventor shall have the same effect, as to such invention, as though filed on the date of the prior application, if filed before the patenting or abandonment of

graph, for the claims as I interpreted them. Finally, I concluded that the claims were invalid under 35 U.S.C. § 102(b) because the invention was described in a printed publication more than one year before the filing date of the CIP application.

On review, the court, to the contrary, found that the ground control device was not a claimed element in any of the three claims.

> The claims of the patent cover solely the orbiting satellite and no other object, device, means, or apparatus.

640 F.2d at 1195, 208 USPQ at 788. This alone could have been the basis of the court's decision. Had the court said nothing more, the defendant could have argued that even though no ground controller is claimed, the patent is still not entitled to the filing date of the parent (1960) application under 35 U.S.C. § 112, first paragraph, and thus is invalid under 35 U.S.C. § 102(b) due to the intervening Cole publication.

The law is clear that in order for plaintiff to be successful in claiming that the patent is entitled to the filing date of the parent (1960) application under 35 U.S.C. § 120, the disclosure of the parent application must be sufficient to enable one skilled in the art to make and use the claimed invention as required by 35 U.S.C. § 112, first paragraph. It is, of course, possible that although the disclosure might enable one

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or termination of proceedings on the first application or on an application similarly entitled to the benefit of the filing date of the first application and if it contains or is amended to contain a specific reference to the earlier filed application."

skilled in the art to make the satellite, the disclosure might not be sufficient to enable one skilled in the art to use the satellite. If the Fig. 12 ground controller material added in the CIP application is found to be needed to enable one skilled in the art to use the satellite, then the Williams patent would not be entitled to the earlier parent (1960) application date even though the ground controller is not part of the invention.

However, the court went on to conclude that:

> The Williams patent is not invalid under 35 U.S.C. § 102(b). The case is remanded to Trial Judge Colaianni to file a recommended decision and findings on the other issues presented.

640 F.2d at 1199, 208 USPQ at 791. In order to support this conclusion, the court, of necessity, must have found that the parent (1960) application complied with the first paragraph of 35 U.S.C. § 112. This is because, as explained above, in order to avoid invalidity under 35 U.S.C. § 102(b), the patent must be entitled to the parent (1960) application filing date. In order to be so entitled, 35 U.S.C. § 120 requires that the parent application comply with the first paragraph of 35 U.S.C. § 112. Thus, defendant is precluded from arguing that the parent disclosure is not enabling in accordance with the first paragraph of 35 U.S.C. § 112.

Further support for this position can be found in the changes the court made to finding of fact 97. The finding was changed to read that the additional material added to the CIP (Fig. 12 and the accompanying description) was not "new material." As far as can be determined, there is no distinction between "new material" and the term of art "new matter." This is

now the law of this case. Since no new matter was added in the CIP, all that additional material must be inherent in the disclosure of the parent application. *Priesmeyer* v. *Rudy*, 411 F.2d 796, 798, 161 USPQ 776, 778 (CCPA 1969); *Textronix, Inc.* v. *United States*, 195 Ct.Cl. 53, 59, 445 F.2d 323, 326-27, 165 USPQ 392, 394, 170 USPQ 100 (1970). Thus, any claims supported by the CIP would be equally supported by the parent application.

Defendant, however, argues that the following comment in the court's decision, as a matter of law, invalidates the patent:

> The problem with the original application * * * was * * * the failure * * * to give sufficient information regarding the ground control device to enable one skilled in the art to practice the invention.

640 F.2d at 1198, 208 USPQ at 790. Although the court's language does appear to track the requirements of the first paragraph of 35 U.S.C. § 112, it was made in a discussion explaining why the plaintiff amended the application. In this context it is clear that "the invention" referred to is the invention claimed early in the prosecution of the CIP application, not the invention finally allowed. As discussed previously, the examiner found this invention to be supported only by the added material of the CIP disclosure, and not entitled to the filing date of the parent application. CIP claims 4-7, 10 and 13 were thus rejected under 35 U.S.C. § 102(b) over the intervening Cole publication. However, when the claims were amended to recite the "control means" in a manner similar to the way it was recited in claim 2 of the original parent application, the Cole rejection

was dropped and never raised again. Clearly, the examiner felt that the claimed invention that was finally allowed was properly supported by the parent application. If he had felt otherwise, he would have repeated the Cole rejection.

In the same statement quoted above, the court refers, without qualification, to "the problem with the original application * * *." While this may appear to indicate that the court felt that there was a problem with the patent application originally filed, a reading of the entire decision clearly dispels any such interpretation. This is made particularly clear when it is recalled that the court found that the CIP application added no new matter. The court was merely explaining what the problem was in the eyes of the examiner.

35 U.S.C. § 112

As explained above, this court's earlier decision precludes consideration of any contention that the parent application fails to satisfy the "description," "enablement" or "best mode" requirements of the first paragraph of 35 U.S.C. § 112. If the parent application satisfies these requirements, then so does the CIP application, because the CIP application included all of the disclosure of the parent application. Consideration of the second paragraph requirement of 35 U.S.C. § 112 that the claims must particularly point out nctly claim the invention has, however, not been precluded by the court's decision.[9]

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[9] The second paragraph of 35 U.S.C. § 112 provides:

"The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention. A

Defendant argues that the claims of the Williams patent are invalid under 35 U.S.C. § 112, second paragraph, because without the ground controller as an element, the claimed combination is inoperative. In support of this argument, defendant cites this court's decision in *General Electric Co.* v. *United States*, 215 Ct.Cl. 636, 653, 572 F.2d 745, 755, 198 USPQ 65, 73 (1978). Although *General Electric* did find some claims to be invalid under 35 U.S.C. § 112 due to inoperativeness, the rationale of that decision is not applicable to the case at bar.

In *General Electric*, this court was presented with claims to a servo-control system of the type used on battleships to drive a gun and turret in unison with the movement of a sighting telescope. The invention was directed to solving the oscillation problems in such systems commonly known as "hunting" wherein the gun, due to inertia and time lags, oscillates about the position of correspondence with the telescope. In order to function properly, the anti-hunting means of the invention had to generate a modifying signal only when the current of the drive motor was changing. Claims 35 and 36 were interpreted by the court as requiring that the anti-hunting means be directly connected to a direct current drive motor because a transformer was not included as an element of either of the claims. *Id.* at 651, 572 F.2d at 753-54, 198 USPQ at 72. The court stated that:

> [W]ithout transformer 81, or some equivalent means, the claimed combination is inoperative

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claim may be written in independent or dependent form, and if in dependent form, it shall be construed to include all the limitations of the claim incorporated by reference into the dependent claim."

> since there would be nothing to prevent the generation of a modifying signal by anti-hunting means 55 under constant current drive motor conditions. Since the combination as claimed is inoperative for its claimed purpose, the patentee has failed to distinctly claim the disclosed invention as required by the second paragraph of 35 U.S.C. § 112. * * * Accordingly claims 35 and 36 are invalid.

215 Ct.Cl. at 653, 654, 572 F.2d at 755, 198 USPQ at 73.

Defendant compares the omission of the ground controller in the claims of the Williams patent with the omission of the transformer 81 in *General Electric* and concludes that the claims of the Williams patent are inoperative. However, the omission in *General Electric* caused the claims there to define a device that would generate a modifying signal when no modifying signal should have been generated. The device as claimed would have been unsuitable for the claimed purpose. In contrast, it is clear that the satellite defined by the claims of the Williams patent would operate properly in accordance with the claimed purpose. All that is needed to use the satellite defined by the claims is a ground controller.

The defendant's argument then boils down to the argument that because the satellite needs a ground controller in order to be used, a ground controller must be claimed. This position has already been dealt with by this court in *Hughes Aircraft Co.* 220 Ct.Cl. __, 640 F.2d at 1197, 208 USPQ at 789, where it is stated that "it is not necessary to claim in a patent every device required to enable the invention to be used."

Defendant further argues that the claims are invalid under 35 U.S.C. § 112, second paragraph, because they are mere aggregations of elements. An aggregation occurs where a claim recites two or more elements without reciting the structural or functional relationship therebetween. Where a claim is found to be a mere aggregation, courts have generally held that the claim does not particularly point out and distinctly claim the invention as required by 35 U.S.C. § 112, second paragraph. *Young* v. *United States*, 179 USPQ 801, 808 (Ct.Cl. Trial Div. 1973), *adopted*, 204 Ct.Cl. 867, *cert. denied*, 419 U.S. 1002 (1974). In this case, even though the ground control is not claimed, the structural and functional relationship between the means for providing an indication of the body position and the fluid expulsion means is clearly set forth in each of the claims. Thus, these claims are clearly not mere aggregations of elements, but rather they each define a cohesive cooperative combination working together to perform the desired function.

35 U.S.C. § 103

Defendant argues, in view of the prior art that the subject matter of the Williams invention as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art and that therefore, in accordance with 35 U.S.C. § 103,[10]

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[10] 35 U.S.C. § 103 provides:

"A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having

the Williams patent is invalid. Defendant has proposed a number of combinations of prior art references. Each combination is claimed to show that the Williams invention would have been obvious. Plaintiff predictably argues that these combinations do not make the invention obvious. For the reasons discussed below, I have found that the invention claimed in each of the three claims of the Williams patent is not obvious.

The Supreme Court, in the case of *Graham* v. *John Deere Co.*, 383 U.S. 1, 17-18 (1966), set forth the following guidelines to be used in determining obviousness:

> Under § 103, the scope and content of the prior art are to be determined; differences between the prior art and the claims at issue are to be ascertained; and the level of ordinary skill in the pertinent art resolved. Against this background, the obviousness or nonobviousness of the subject matter is determined. Such secondary considerations as commercial success, long felt but unsolved needs, failure of others, etc., might be utilized to give light to the circumstances surrounding the origin of the subject matter sought to be patented. As indicia of obviousness or nonobviousness, these inquiries may have relevancy.

Scope and Content of the Prior Art

Although numerous prior art references were introduced into evidence. Dr. William B. McLean's work is the most pertinent. This work is disclosed in

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ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made."

U.S. Patent No. 3,216,674, filed June 8, 1959, and issued November 9, 1965. Both sides agree that the McLean patent is prior art to the CIP Williams patent. The McLean patent '674 was first cited in the prosecution of the Williams case in the January 10, 1966, office action. Soon thereafter, plaintiff decided to obtain an exclusive license under the patent. On May 15, 1967, an application for reissue of the original McLean patent '674 was filed in order to broaden the disclosure and claims. This application matured into reissue patent, Re. 26,887, on May 19, 1970. The parties, moreover, do not agree that the McLean reissue patent is a prior art reference with regard to the Williams patent, which was originally filed on April 18, 1960. As the disclosures of both the original patent and the reissue are nearly identical, the original patent will be discussed first.

The McLean device is closely related to the so-called "smart" missile technology developed during the 1950's, and in particular to the Navy's Sidewinder missile, with which Dr. McLean was intimately involved.[11] The Sidewinder missile is intended to automatically track, follow, and destroy moving targets (especially planes) within the earth's atmosphere. It is contemplated that the target will attempt evasive maneuvers, but that the missile will constantly monitor these movements and make the necessary changes in course to ensure collision. The tracking device, positioned in the head of the missile, is a gyroscope having a Cassegrainian telescope[12]

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[11] Dr. McLean was a member of the project staff for the Sidewinder missile.

[12] A Cassegrainian telescope is a form of reflecting telescope in which the rays are reflected from a primary mirror to a

located such that its optical axis is aligned with the axis of rotation of the gyroscope. An infrared detector is positioned in the focal plane of the telescope. Once the missile gets an infrared ray emitting target (for example, the engines of a jet plane) within the sight of the telescope, the tracker follows it, attempting to keep the target in the center of the telescope's field of view. This information is interpreted within the missile and relayed to the control fins so that the missile is kept on a collision course in accordance with the principles of proportional navigation.[13]

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smaller secondary mirror and then through an opening in the primary mirror to the eye of the observer.

[13] A brief discussion of the principles of proportional navigation follows.

The object of proportional navigation is to set a collision course for a missile with a moving target. First, it is important to realize that a finite amount of time will elapse between the time the missile is launched and the time of collision with the target. During this time, the target will have changed positions. In order to account for this, the launcher must anticipate where the target will be when the missile finally gets in the area of the target. It turns out that a missile is on a collision course with a target when the range between the missile and the target is closing and the angle between the path of movement of the missile (the course line) and the line connecting the moving target and the missile (the sight line) remains constant. An example of this concept is shown in Fig. 16 of McLean which is reproduced below.

[image omitted, see 30 Cont. Cas. Fed. (CCH) ¶ 70,298, at 75,313]

Fig. 16 of McLean

Element 10 in the figure is the missile. The figure shows the relative position of the target and missile at four equally spaced instants of time.

The U.S. patent to Guthrie, *et al.*, No. 3,010,677, which was filed on November 12, 1957, and issued on November 28, 1961, is a good example of the Sidewinder-type seeker system. Figure 2 of Guthrie, *et al.*, reprinted below, shows the transparent front end 24 of the missile and the rotating gyroscope 16. The Cassegrainian telescope (*see* mirrors 16 and 17) is mounted as a part of the gyro

[image omitted, see 30 Cont. Cas. Fed. (CCH) ¶ 70,298, at 75,314]

Fig. 2 of Guthrie

and is used to monitor the position of the infrared ray emitting target so that the angle between the path of movement of the missile (the course line) and the line connecting the moving target and the missile (the sight line) can be determined. The axis of the telescope points along the sight line at the target and as a result the spin axis of the gyro (which is coincident with the optical axis of the telescope) is seldom positioned in line with the course line of the missile. When a change in the target position is detected, the gyro 16 is precessed[14] magnetically (using coils 27) so that the spin axis of the gyro is

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Guiding a missile under the principles of proportional navigation involves (1) maintaining a closing range between missile and target and (2) maintaining the angle between the course line and sight line constant. Although this is not a complete explanation, for the purposes of this case, all that need be kept in mind is that when a change in the angle between the course line and sight line is detected, the missile direction must be changed in an amount proportional to the rate of change of the angle in order to maintain a collision course with the target.

[14] *See* n. 3, *supra*.

maintained in alignment with the target. This information is then relayed to the adjustable control surfaces which act to change the course of the missile as needed. In the particular missile described in Guthrie, the control surfaces are retractable wings.

Applying the principles he was aware of from the Sidewinder project, Dr. McLean came up with a target-seeking vehicle useful for applications in outer space. Realizing that aerodynamic forces are not a factor in the vacuum of space, he decided that the entire vehicle could be set spinning and used as the gyroscope needed to determine the angle between the course line of the vehicle and the sight line from the vehicle to the target. McLean's vehicle is shown in fig. 1 of the patent, which is reproduced below.

[image omitted, see 30 Cont. Cas. Fed. (CCH) ¶ 70,298, at 75,315]

Fig. 1 of McLean

As can be seen, the Cassegrainian telescope (*see* mirrors 18 and 19) is mounted on a spinning frame with the detector 12 positioned at the observation point of the telescope. The detector provides the information about the position of the target with respect to the spin axis of the vehicle (which is coincident with the telescope axis) that is needed to maintain the vehicle on a collision course with the target. In the Sidewinder missile, this information is used to precess the gyro into alignment with the target and to change the course of the missile. In the vehicle of McLean, the information is used to precess the entire space vehicle into alignment with the target and to change the course of the vehicle. However, the means used to provide these functions in the Sidewinder missile (electromagnets and adjust-

able control surfaces) would simply not work for McLean's space vehicle.

Dr. McLean knew from basic gyroscope dynamics that in order to precess his spinning space vehicle he needed to provide a torque about an axis perpendicular to the spin axis of the vehicle. In order to provide this torque, Dr. McLean positioned a precessing jet 16 near the edge of the vehicle, spaced from the spin axis and aligned such that the thrust force of the jet is along a line parallel to the spin axis. The portion of the spin cycle during which the jet is pulsed determines the direction of precession.

The precessing jet changes only the orientation of the spin axis of the vehicle. In order to change the course, McLean provides a lateral jet 32 pointing outwardly from the edge of the vehicle such that the thrust force of the jet is directed through the center of mass of the vehicle. The portion of the spin cycle during which the lateral jet is pulsed determines the course correction. McLean assumes that a forward velocity is imparted to the vehicle when it is launched into outer space so that no additional forward thrust is needed. (*See* col. 6, lines 65-68, of McLean.)

[image omitted, see 30 Cont. Cas. Fed. (CCH) ¶ 70,298, at 75,316]

Fig. 3 of McLean

Figure 3 of McLean is reprinted here as an aid in explaining how the detector system works. Reticle 20 is placed in the focal plane of the telescope with an infrared detector 22 positioned directly behind it. The reticle is a thin circular element divided into two halves with a line through the middle. One-half is transparent, and the other is opaque. When the telescope gets the infrared ray emitting target within its

field of view, the image appears at the reticle. If the target is aligned with the telescope axis, then, as the vehicle and the reticle spin, the photodetector 22 detects only a constant amount of infrared radiation because the image of the target is in the center of reticle.

If the target, due for example to relative acceleration, should move away from alignment with the axis of the telescope, the image of the target will be blocked from the detector 22 during half of the spin cycle and permitted to pass during the other half. This results in an alternating signal being provided by the detector 22.

As will be seen later, when the differences between Williams' claimed invention and the structure of McLean are compared, it is important to ascertain exactly how much information this alternating signal provides. In this connection, it may be useful to consider the line dividing the reticle 20 into opaque and clear halves together with the spin axis (or telescope axis) as forming an imaginary plane spinning at the same rate as the space vehicle. When the current from the detector 22 goes from low to high, the imaginary plane has swept past the target and the image of the target has gone from the opaque portion of the reticle to the clear part. This provides enough information to determine when during the spin cycle the precessing jet needs to be fired in order to precess the spin axis towards alignment with the target. The detector 22 is connected through an amplifier to the precession jet sc that every time the signal goes from low to high, the jet is activated. By positioning the jet properly with respect to the reticle, the jet is activated during the correct portion of the spin cycle to provide the desired precession (toward the target).

Additionally, in order to make adjustments without the need to physically change the position of the reticle, a phase-shifting circuit is provided. The signal that activates the precession jet simultaneously activates the lateral jet in order to maintain the spinning vehicle on a collision course.

In a preferred embodiment of the reticle, McLean provides alternately opaque and clear segments in the clear halt of the reticle. Because the segments are shaped like pie slices, a target that is close to alignment and provides an image close to the center of the reticle will be partially obscured by the edges of the segments at all times. When the image of the target is further from the center, more of it will be exposed to the detector. The resulting differences in current are proportional to the angle between the spin axis and the line of sight to the target. These differences in current are applied through an amplifier to vary the thrust from the jets—a higher thrust being applied where the angle is greater.

Because the vehicle of McLean is a target seeker, it would be desirable to eliminate as many extraneous signals as possible. Although the disclosure appears not to address this issue, it is clear that the field of view of the telescope must be fairly narrow. One of defendant's witnesses at trial suggested that the field of view is of the order of 8 to 10 degrees.

Although the McLean space vehicle was developed in the context of seek-and-destroy-type missiles, there appears to be no discussion of any particular use apart from general navigation towards a target. The disclosure at col. 2, lines 63-64, of McLean suggests that the target could be the moon, a planet, or some other space vehicle.

The McLean Reissue

As mentioned previously, the plaintiff, soon after becoming aware of the original McLean patent (U.S. Patent No. 3,216,674) acquired an exclusive license under it. Plaintiff filed for a reissue patent on May 15, 1967, which application matured into reissue patent Re. 26,887 on May 19, 1970. The issue here is whether this patent is prior art to the original Williams patent, which was filed April 18, 1960.

However, there is no need to decide this issue, because the disclosure of the McLean reissue adds nothing of significance to what was disclosed in the original McLean patent. The only possible argument that something of substance has been added appears to be that the broader introductory statements made in the reissue indicate that uses other than proportional navigation were contemplated. Even if accepted as true, this inference would not aid defendant in establishing obviousness. The only embodiment disclosed in the reissue is the one disclosed in the original application. There is no suggestion of what, if any, the other uses might be. A broad suggestion that other uses may be found does not aid one of ordinary skill in the art to determine what those uses are. Thus, there is no need to decide whether the reissue is prior art to the Williams patent because the reissue adds nothing to the original disclosure. All further references to "McLean" are intended to be to the original McLean patent (No. 3,216,674).

Additionally, in connection with the McLean reissue patent, defendant makes an argument that is applicable to both the obviousness issue and the inequitable conduct issue. Defendant, in particular, argues that the McLean reissue is relevant because

the claims in the reissue patent cover "and therefore describe" spin-stabilized satellites like the one disclosed in Williams. (*See* pp. 105-06 of defendant's post-trial brief, part II, vol. 1.) If the mere fact that a claim in the McLean reissue patent covers the satellite structure disclosed in Williams meant that the McLean reissue patent described the Williams satellite, then the issue of whether or not the McLean reissue is prior art would have to be decided. However, it is basic in patent law that a claim in a patent can cover or dominate a later invention without fully describing the later invention. *Deitel* v. *La Minuette Trading Co.*, 37 F.2d 41, 4 USPQ 92 (2d Cir. 1930). For example, a patent with a claim to a television set would cover and dominate a later invention to the combination of the same television set, plus a remote control. There is no need to describe the remote control in the disclosure of the earlier patent because it does not form part of the invention in the earlier patent. There is no description of spin-stabilized satellites in the McLean reissue, and the fact that the claims may cover such satellites does not magically provide any absent disclosure. The issue under 35 U.S.C. § 103 is whether the later invention is obvious in view of the disclosure of the prior art patents, not whether the claims of the prior art patents read on the later invention.

Other Prior Art

Two other prior art references are of interest and will be briefly discussed. The U.S. patent to Null, et al., Patent No. 2,955,777, filed August 19, 1946, and issued October 11, 1960 shows an automatic target-seeking missile for use within the earth's atmosphere. Radiation emitted from the target is detected

in the front end of the missile and used to make course corrections automatically where necessary. The interesting fact for the purposes of this case is that Null, *et al.*, suggests that in order to prevent the missile from accidentally acquiring the heat emitting engines of the mother plane as a target, a remote control system should be provided at the launching station (the mother plane in Null, *et al.*) which is capable of overriding the automatic controls.

The other patent, No. 3,396,920, filed December 30, 1959, issued on August 13, 1968, to Harold A. Rosen and Donald D. Williams. Donald D. Williams is, of course, the sole inventor of the patent in suit. The '920 patent was discussed previously and discloses a spin-stabilized satellite for use especially in an orbit synchronized with the spin of the earth. Rosen, *et al.*, uses a directional antenna aligned with the spin axis and solves the orientation problem by stopping the spin, changing the position of the satellite, and then starting the spin up again. All of this is done by remote control from the ground.

The Differences Between the Claims of Williams and the Prior Art

Defendant's basic argument is that the McLean device includes all the elements of the claims of Williams except for the remote control aspect, and that provisions for remote control would have been an obvious addition to the device of McLean. This argument fails because, as explained below, the device of McLean does not include all of the elements of the claims of Williams, except for the remote control.

The element of claim 1 that gives defendant the most trouble in this regard is (e). There is no need to discuss the other two claims separately because they

contain substantially the same subject matter with differences that are not material to the issues involved here. Element (e) of claim 1 reads:

> e. means disposed on said body for providing an indication to a location external to said body of the instantaneous spin angle position of said body about said axis and the orientation of said axis with reference to a fixed external coordinate system; * * *.

At trial, when the defendant's expert witness, Mr. Wilhelm, was asked to compare this language with the device of McLean, he said: "Well, that one starts to give me a little trouble." Mr. Wilhelm went on to indicate that the McLean telescope sensor does not fit the classical definition of indicating the spacecraft's instantaneous spin angle position and spin axis orientation with reference to a fixed coordinate system. He also hastened to add that while McLean did not provide the claimed indications, neither did Williams. Prior to the court's earlier decision in this case, defendant's position on this point was that: [T]o the extent * * * the Williams apparatus can be considered to determine [the claimed] relationship, McLean does the equivalentnd there is no difference between these two systems.

This court, in the decision of December 17, 1980 (*Hughes Aircraft Co.* v. *United States*, 226 Ct.Cl. __, 640 F.2d 1193, 208 USPQ 785 (1980)), adopted most of the findings of fact made at the trial level. *Id.* at __, 640 F.2d at 1193, 208 USPQ at 786. These findings are now established facts of the case. Findings 33-61 show that the disclosure supports the recitations of the claims, and particularly the means for providing

the indication to the earth station required by section (e) of claim 1.

Defendant's former argument that both McLean and Williams are equally deficient is no longer valid. Defendant must show that McLean meets every element of the claim except for the remote control in order to support its obviousness argument. On this issue, defendant has the burden of proof. *Aluminum Co. of America* v. *Amerola Products Corp.*, 552 F.2d 1020, 1024, 194 USPQ 1, 4 (3rd Cir., 1977); *Laser Alignment, Inc.* v. *Woodruff & Sons, Inc.*, 491 F.2d 866, 871, 180 USPQ 609, 611 (7th Cir., 1974), *cert. denied*, 419 U.S. 874 (1974). The defendant has failed to meet this burden. In order to understand why, it is necessary to understand the technical requirements of the Williams claims and the functioning of the McLean target-seeking space vehicle.

The best place to start is to look at what it is that element (e) of claim 1 of Williams requires. Element (e) calls for means providing an indication of the instantaneous spin angle position (ISA) of the spinning body with reference to a fixed external coordinate system. A fixed external coordinate system is one fixed with respect to the distant stars. The instantaneous spin angle position (ISA) with reference to a fixed external coordinate system is more difficult to define. In order to precess the body in a predetermined direction, it is necessary that the angle between the line connecting the precessing jet with the center of mass of the body and the plane formed by the line connecting a known reference point in an external coordinate system (*e.g.*, the sun or a star) with the center of the body and the spin axis be known for any given instant of time. This angle, when given for a particular instant of time, is the instantaneous spin

angle position with reference to a fixed external coordinate system. The minimum amount of information needed to determine the ISA with respect to a fixed external coordinate system is (1) the spin rate of the body, and (2) the instant in time at which the plane formed by the spin axis of the body and the line connecting the precessing jet with the center of mass of the body sweeps past a known fixed point (*e.g.*, the sun or a star) in a fixed external coordinate system.[15]

Additionally, element (e) requires means for indicating the orientation of the spin axis of the body with reference to a fixed external coordinate system. The meaning of this requirement is apparent on its face. Element (e) of claim 1 requires that there be an indication provided of both the ISA and the spin axis orientation. Elements (f) and (g) go on to explain that this information is to be used to generate synchronized signals to control the pulsing of the axial jet:

> [F]or precessing said body to orient said [spin] axis in a predetermined desired relationship with said fixed external coordinate system.

In order to perform the claimed function, it is necessary that both the indication of the ISA and the indication of the spin axis orientation be provided at the remote location at the same time.[16] This is because in order to precess the body into a desired orientation within a fixed external coordinate system,

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[15] The direction of spin must also be known, but for all spacecraft considered in this opinion the direction of spin is assumed to be known because the spin is intentionally induced.

[16] This does not mean that the information from which the ISA and orientation is determined must be transmitted at the same time. It only means that both the ISA and orientation must be known on the ground at the same time.

the initial orientation must be known, and in order to pulse the jet in the proper portion of spin cycle to provide the torque needed for the desired precession, the angular position of the axial jet must be known. Thus, claim 1 requires that the indication of the ISA and the indication of the spin axis orientation be provided at the same time, since otherwise the device would not be capable of performing the claimed function.

The space vehicle of McLean is designed to maintain a collision course with a target. The Williams satellite is designed to maintain its spin axis in an orientation parallel to the earth's spin axis while in synchronous orbit around the earth. Although both devices use an axial jet pulsed synchronously with the spin cycle for changes in orientation, the differences in function lead to important structural differences in the two devices. Because the space vehicle of McLean is designed to maintain its spin axis pointed at an infrared emitting target, the sensor is directed along the spin axis. In order to reduce the possibility of confusion with other infrared emitting objects, the field of view of the telescope which focuses the image of the target on the sensor is fairly narrow (of the order of 8 to 10 degrees).

The satellite of Williams uses the sun as its reference point in a fixed external coordinate system to determine the ISA and to help determine the orientation of the spin axis. In Williams, it is desirable to sense the sun in as wide a range of satellite orientations as possible while maintaining a lightweight design. Thus, the sensor in Williams consists of two slits (one parallel to the spin axis and one at an angle) in the outer skin of the satellite, each one having a sensor mounted behind it so that as the slits in the

satellite spin past the sun the sensors are illuminated. The optical field of view using this setup is about 140 degrees centered about a line perpendicular to the spin axis. The fact that the sun emits such a large amount of radiation makes the chance of confusing the sun signal with other lower level radiation emitting objects negligible.

The time lapse—between the determination that a course change is necessary and the implementation of the course change—is critical in the context of target seeking, particularly where the target is moving. Because of this, the space vehicle of McLean is wired to provide both course correction and orientation correction at the same time that the sensor discovers that such corrections are needed. In Williams, the time lapse is not as critical. Once the satellite of Williams is placed in synchronous orbit around the earth, the orientation needs to be changed so as to align the spin axis of the satellite with the earth as soon as possible. This orientation provides optimal antenna reception. There is no need, however, to change the orientation immediately. As a result, the satellite is wired so that no orientation correction is made until the ground controller decides that it is time to make a correction.

Despite these differences in structure and operation, defendant argues that the McLean space vehicle provides the information required by claim 1. To arrive at this conclusion, defendant takes me down a fairly rocky logical road. Initially, for purposes of this opinion, I have been asked to assume and will assume, as defendant has, that the position of the center of the McLean vehicle would be known for any given instant of time through the use of range tracking, and that the McLean target can be a star.

As I begin my analysis, it is important to recall that the space vehicle of McLean can be treated as having two modes. The quiet mode is when the spin axis of the vehicle is directly aligned with the target. Only a steady signal is produced by the sensor. The alternating mode occurs when the spin axis is out of alignment with the star. During this mode, an alternating signal is produced as the target image falls on the dark and then the clear parts of the reticle.

When the sensor emits a steady state signal, the orientation of the spin axis in a fixed external coordinate system can be determined. This is because the position of the satellite with respect to the earth is known through range-tracking techniques, and the signal indicates that the spin axis is pointing directly at a known star. However, there is no indication of the instantaneous spin angle position, because the sensor is providing only a steady state signal. When the sensor signal is alternating, the instantaneous spin angle position with reference to a fixed external coordinate system can be determined.[17]

In the case of McLean, it is best to view the rotating imaginary plane as being defined by the spin axis and the line between the opaque and the clear portions of the reticle. The position of the axial jet with respect to this plane is known. Thus, after the second time this plane sweeps past the star as indicated by the signals generated by the sensor, the angular velocity (*i.e.*, the spin rate) of the vehicle can

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[17] To make this determination, defendant assumes that it would take at least two successive pulses from the precession jet before the spin axis is aligned with the star. As plaintiff has made no objection to this assumption, and since it appears likely that at least in some cases two or more successive pulses would be needed, I accept defendant's assumption.

be determined.[18] The time at which the plane sweeps past the target star (which is fixed in an external coordinate system) is determined by observing when the sensor changes from a low signal to a high signal. In accordance with the definition discussed earlier, this is enough information to determine the instantaneous spin angle position.

The orientation of the spin axis, however, cannot be determined without ambiguity while the McLean device is in the alternating signal mode. The position of the target star in a fixed external coordinate system is known. The angle (let us call it the "star angle") between the line connecting the star to the center of the vehicle and the spin axis of the vehicle is known because of the relative intensity of the sensor signal. The position of the vehicle is known through the use of range-tracking techniques. However, this information still does not define the orientation of the spin axis of the vehicle with respect to a fixed external coordinate system. The spin axis may lie anywhere within a "cone of ambiguity." This may be illustrated with the aid of a pair of scissors. Call the long blade the line between the star and the center of the vehicle and the short blade the spin axis. The angle between the blades is the star angle. The scissors may be rotated about the long blade, so that the short blade assumes a variety of orientations without changing the angle between the blades. As the scissors are rotated, the short blade describes what a mathematician would call a cone of revolution,

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[18] This result is not affected by the fact that between signals the orientation of the vehicle has changed. This is because the precession is in a direction towards the target star.

and what in this case is referred to as a cone of ambiguity.

Of course, for the purposes of McLean, there is no need to resolve this ambiguity. All McLean needs to know to precess towards the target is the relative position of the spin axis and the axial precession jet with respect to the target. In Williams, however, the ambiguity must be resolved in order to permit changes in orientation to a predetermined orientation *within a fixed external coordinate system.* It is the means for providing this additional information in combination with the remote control which was stressed as the major distinguishing feature in arguments made by the plaintiff before the examiner during the prosecution of the Williams application.

Defendant, however, points out that the disclosed embodiment of Williams, like McLean, only provides an indication of the angle between the line from the sun to the center of the satellite and the spin axis. Thus, just as in McLean, more information is needed in the disclosed embodiment of Williams to resolve the ambiguity. Unlike the situation with McLean, however, findings of fact 33-61 made at the trial level and adopted by the court show that the disclosure in the Williams patent is sufficient to support the language of the claims. The claims require an unambiguous indication of the orientation of the spin axis in a fixed external coordinate system. In discussing the cone of ambiguity problem of the Williams satellite, the court found:

> 45. The existence of these ambiguities and the techniques for overcoming them would have been obvious to any person of ordinary skill in the art of celestial navigation.

> 46. Such a person would know that these ambiguities could be resolved in at least two different ways: by dead reckoning; or by adding an earth sensor. The disclosed embodiment does teach the use of an antenna with an asymmetric radiation pattern as a crude earth sensor.

Hughes Aircraft Co., 640 F.2d at 1215, 208 USPQ at 805.

Defendant boldly points to these findings and claims that the McLean cone of ambiguity "is of no patentable significance" because it can be overcome in any of the ways suggested in the findings. However, these findings deal exclusively with the Williams satellite. There is no suggestion from the findings that they would be applicable to the target-seeking space vehicle of McLean. Furthermore, it appears likely that these findings would not apply to McLean due to the functional and related structural differences between the McLean and the Williams devices.[19] Finally, even if the techniques suggested in the

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[19] Where dead reckoning is selected as the means for providing the extra information, it might be argued that the only difference between McLean and Williams relates to intended use. This, however, would not be accurate. Because of the differences in structure, including selective remote control of the jet pulses from the ground instead of automatic course correction pulses and the different sensor setups, the device of Williams is physically adapted to take advantage of the dead-reckoning procedures suggested by the findings. It is not at all clear that these same procedures would work in the case of the McLean vehicle. Indeed, there has been no testimony to that effect. The physical differences in the Williams satellite which permit the dead-reckoning procedures to work are part of the claimed means for providing an unambiguous determination of the orientation of the spin axis in a fixed external coordinate system.

findings could be used in McLean, there is no reason to do so because McLean does not need the extra information.

Defendant has the burden of proof on this issue. However, defendant fails to direct the court to any evidence in the record showing that the McLean device provides the claimed indication. Instead, the court is asked to infer that McLean provides an unambiguous indication of the orientation of the spin axis during the alternating signal mode (*i.e.*, where the spin axis is out of alignment with the target star) from findings that one of ordinary skill in the art would recognize the ambiguity problem in Williams and know how to solve it.

As should be obvious by now, the issues are different. The court's previous findings were directed at establishing whether or not the language of the claims of the Williams patent was supported. This court found that it was, because unambiguous knowledge of the orientation of the spin axis in an external coordinate system is necessary to the operation of the Williams device and the means for providing this information was well known in the art. In defendant's argument, the issue is whether the McLean vehicle, which does not need the extra information, nevertheless provides means for resolving the cone of ambiguity associated with its indication of the orientation of the spin axis during the alternating signal mode. Not only are there no findings directed specifically to this issue, but defendant's own witness, Mr. Wilhelm, indicated that the information provided by McLean does not fit the classical definition of indicating the spacecraft's instantaneous spin angle position and spin axis orientation with reference to a fixed coordinate system.

As defendant relies solely on these findings, defendant has failed to satisfy its burden of proof on this issue.

In sum, during the alternating signal mode, where the spin axis of McLean is out of alignment with the target star, McLean provides an indication of the instantaneous spin angle position, but not the orientation of the spin axis within a fixed external coordinate system. During the quiet mode, where the spin axis is aligned with the target star, McLean provides an indication of the orientation of the spin axis, but not the instantaneous spin angle position, within a fixed external coordinate system. As previously discussed, the claims require that the ISA and orientation be indicated at the same time in order to permit controlled precession in a fixed external coordinate system. It follows then that defendant's basic obviousness argument that McLean has every element called for in the claims except the remote control must fail.

In the above analysis, the differences in function between the McLean and Williams devices which are reflected in structural differences has been stressed. Additionally, as discussed above, these differences are reflected in the claim language. Specifically, wherein Williams calls for an indication of the orientation of the spin axis within a fixed external coordinate system, McLean does not. Defendant argues that the distinction between the functions of the two devices should not be given much weight, however, because the specification of the Williams patent indicates that the concept of Williams could be used in constructing a target-seeking vehicle in accordance with proportional navigation principles. The problem with this argument is that the claims in issue were narrowed by amendment in response to the examiner's citation

of the McLean reference many years after the original application was filed. Although the claims of Williams do not specifically exclude coverage of all target-seeking vehicles, they call for means which the McLean vehicle does not have. Thus, to the extent that target seekers do not include the claimed elements, the claims of Williams do not cover them.

Level of Ordinary Skill in the Art

Although failure of the defendant's basic obviousness argument disposes of most of the 35 U.S.C. § 103 issues, two minor arguments should be discussed. After a careful review of the record, I have determined that the level of ordinary skill in this art was that of an aerospace engineer practicing in 1960 with some exposure to the problems of synchronous orbit telecommunication satellites. In accordance with 35 U.S.C. § 103, the question is whether defendant's proposed changes to McLean would have been obvious to such a person.

In order to show that the teaching of McLean could have been modified to accomplish the same result as Williams, defendant argues that it would have been obvious to close the lateral course correction jet of McLean. Next, the defendant apparently argues that it would have been obvious to mount the McLean sensor on the side of the McLean space vehicle. If these changes were in fact obvious, the McLean space vehicle would begin to look structurally much more like the satellite of Williams. However, in order to be obvious, such changes must somehow be suggested in the art.

In any consideration of obviousness, it is always necessary to be vigilant against the possibility of hindsight creeping into the analysis. One way that

the courts have guarded against hindsight is by insisting that the reason for making the suggested changes be apparent at the time the invention was made to a person of ordinary skill in the art. *In re Nomiya, Kohisa and Matsumura*, 509 F.2d 566, 184 USPQ 607 (CCPA 1975). Here, there is simply no suggestion in the art to make these changes and thus they would not have been obvious. Furthermore, it is generally settled that a change in a prior art device which makes the device inoperable for its intended purpose cannot be considered to be an obvious change. *Block* v. *Nathan Anklet Support Co.*, 9 F.2d 311, 312 (2d Cir., 1925); *Diamond International Corp.* v. *Walterhoefer*, 289 F.Supp. 550, 559, 159 USPQ 452, 460-61 (D.Md., 1968); *L.E. Sauer Machine Co.* v. *Corrugated Finishing Products, Inc.*, 642 F.2d 203, 210 USPQ 81 (7th Cir., 1981). In the case at bar, it is clear that if the McLean space vehicle were modified as suggested it would no longer be capable of performing its intended target-seeking function. Thus, the suggested changes are not obvious changes.

Inequitable Conduct

In over 130 pages directed to the issue of inequitable conduct, defendant in its brief makes only two points that are considered worthy of some discussion. First, defendant claims that the plaintiff made statements to the examiner about the McLean reference which were untrue and inconsistent with statements made when obtaining the McLean reissue. Second, defendant claims that the plaintiff should have, but did not cite the McLean reissue to the examiner, the Board of Appeals and the CCPA as relevant prior art. Defendant argues that this conduct amounts to unclean hands in the prosecution of the patent application and should result in the patent being held unenforceable.

However, as will be explained below, the acts or omissions cited by defendant did not amount to unclean hands.

None of the numerous statements made by the plaintiff and quoted by the defendant can be considered to be either untrue or inconsistent. The statements in question were made in plaintiff's April 29, 1966 response to the examiner's January 10, 1966, rejection. In this rejection the examiner, for the first time, cited the McLean patent (No 3,216,674). Both the examiner and the plaintiff immediately recognized the relevance of McLean. They both saw that although McLean was not designed for earth orbit, it clearly disclosed the basic synchronously pulsed jet precession concept which plaintiff had broadly claimed. As a result, plaintiff in its April 29, 1966, response severely contracted the scope of its claim coverage to avoid the McLean reference.

The newly submitted claims were accompanied by about 11 pages of remarks which explained the plaintiff's interpretation of the cited references (including McLean) and the plaintiff's explanation of how it thought the new claims avoided these references. A few examples of the quoted comments will suffice to capture the flavor of the remarks. Plaintiff argued in the response that:

> McLean's infrared telescope does not indicate the instantaneous spin angle position of his body *with reference to a fixed external coordinate system, and it does not indicate the orientation of the axis with reference to a fixed external coordinate system.* * * * No fixed external coordinate system is involved [in McLean].
>
> * * * * *
>
> McLean's device would be incapable of performing the function of applicant's claimed invention; namely re-orienting the spin axis to point in a desired direction while in orbit. It is only capable of pointing the spin axis at a target.
>
> * * * * *
>
> There is no thought [in McLean] of orienting the spin axis of a satellite in orbit. [Emphasis in original.]

Although some of these statements may be argumentative, each is supportable by reference to the McLean disclosure. In fact, the view that I have taken of the McLean patent after a careful review of the record is quite similar to that expressed by plaintiff many years before this litigation began.

The first statement listed above has two parts—one dealing with ISA, and one with orientation. It is clear from my consideration of the obviousness issue, that McLean never indicates both the ISA (instantaneous spin angle position) and the orientation at the same time as required by the claims of Williams. Instead, only one of these is literally present for each of the two modes of McLean. In the alternating mode, only the ISA is known; and in the quiet mode (with the axis pointed at the target star), only orientation is known. It should, moreover, be remembered that defendant made a number of assumptions in order to even be able to make its rather feeble case on obviousness. For example, it was assumed that the target was a star. However, it is certainly arguable that the target could not be a star, as McLean makes no mention of stars as targets in the specification. If the target were not a star, then it is not at all clear that McLean would ever indicate either the ISA or the orientation with respect to a fixed coordinate system. This is because McLean does not need this information to perform its desired function.

The second statement is also correct. On the one hand, since the McLean vehicle automatically precesses towards the target, no fixed external coordinate system is needed. On the other hand, since the Williams satellite is capable of reorienting itself from one known position to another within the external coordinate system, a fixed external coordinate system is quite necessary. This reorientation is made possible in Williams by providing more complete information about the ISA and orientation in combination with means for permitting ground control of the satellite. There can be no question that the examiner understood what the plaintiff was saying. The

examiner had the McLean reference in front of him at all times and could immediately compare all of plaintiff's statements with the McLean disclosure.

The third statement quoted above is patently true from a reading of the McLean patent. There is simply no discussion of use of the McLean device in orbit, or, for that matter, of reorienting the spin axis of the McLean device while it is orbiting the earth.

Furthermore, even if these statements could somehow be interpreted as being misleading or untrue, it is far from clear that such conduct should make an otherwise enforceable patent unenforceable. If the plaintiff makes a mistake in interpretation, it is the examiner's duty to recognize this and act accordingly. No examiner worth his salt would thoughtlessly accept the word of an applicant as to the relevance of a cited reference without verifying it.

Defendant cites some cases in support of its argument that plaintiff's representations regarding the McLean reference make out a case of inequitable conduct, but in each case the conduct has involved the omission or misrepresentation by the applicant of facts which cannot be independently discovered or confirmed by the examiner. Those cases are inapposite in situations such as the one at bar where the examiner has the reference being discussed right in front of him.

Defendant also contends that inconsistent statements made by the plaintiff regarding the McLean patent in connection with its April 1966 response in Williams and during the prosecution of the McLean reissue patent amounts to inequitable conduct. As the McLean reissue was filed on behalf of the plaintiff, it is fair to consider statements made during its prosecution as attributable to the plaintiff. A

comparison of a representative pair of statements will show that defendant's argument is without merit.

In the remarks of the April 1966 response, plaintiff states:

> McLean * * * is [not] concerned with orienting the spin axis of a satellite in orbit by precession. * * * [McLean does not disclose] apparatus which could produce such a mode of operation or result.

In the reissue declaration, the plaintiff, through the inventor, William B. McLean, said:

> [T]hat he claimed less than he could rightfully have claimed in the patent in that all the claims therein were inadvertently limited to specific applications of the invention to the field of self-contained proportional navigation apparatus for following a collision course to a target body, whereas the invention is not so limited, but has utility generally where control of the velocity and attitude of a spinning body is desired as in artificial satellites of the earth; * * *.

Defendant merely points to these statements and claims that the inconsistency is apparent. However, it is not apparent to me, and in fact it is clear that these statements are fully consistent. In each case the issues are different. In the case of the April 1966 response, the question is whether the invention claimed by Williams is disclosed by McLean. As discussed previously, it is not, and that is what plaintiff is pointing out. Although McLean has some of the apparatus (*i.e.*, the pulsed precession jet) needed to perform the function of orienting the spin axis of a satellite in orbit by precession in accordance with the teaching of Williams, it clearly does not have

all the apparatus disclosed by Williams to produce such a mode of operation.

In the case of the reissue declaration, the question is whether or not through inadvertent error the original patent is partly inoperative to protect McLean's invention by reason of the fact that it claims less than he had a right to claim in the patent, 35 U.S.C. § 251. In order to show this, plaintiff points out what would be obvious to anyone who understands both McLean and Williams. That is, that the pulsed precession jet concept used to precess the McLean vehicle could be used to precess and thus change the orientation of any spinning space body, but that the original claims of McLean were limited to the target-seeking application.

It is, of course, hornbook patent law that the disclosure of a specie entitles the inventor to claim not only the disclosed specie, but also the genus. Thus, McLean would not only be entitled to claim the disclosed target-seeking structure, but he would also be entitled to broadly claim the precession jet structure. Thus, the fact that a portion of the McLean system (the precession jet) could be generally claimed for precessing a satellite does not mean that McLean discloses the use of its pulsed precession jet concept with a satellite. In fact, McLean does not. Defendant's contention that plaintiff's statements are inconsistent must, therefore, be rejected.

Finally, defendant argues that the McLean reissue patent is prior art to Williams and should have been cited to the examiner, the Board of Appeals, and the CCPA. The question of whether the McLean reissue is prior art has previously been considered in the 35 U.S.C. § 103 portion of this opinion. There was no need to decide the question there because the broad-

ened disclosure of the McLean reissue was found to add nothing of significance to the original McLean disclosure. Here, as will be shown below, there is also no need to decide whether the McLean reissue is prior art because, even if it is prior art, plaintiff's conduct did not amount to unclean hands.

The proceeding before the examiner in the Patent and Trademark Office is *ex parte* and the examiner has no power to investigate and check factual assertions made during the prosecution. For this reason, the applicant must be held to a high standard of candor and good faith. *Precision Instrument Mfg. Co.* v. *Automotive Maintenance Mach. Co.*, 324 U.S. 806 (1945); *Kingsland* v. *Dorsey*, 338 U.S. 318 (1949); *Corning Glass Works* v. *Anchor Hocking Glass Corp.*, 253 F.Supp. 461, 470, 149 USPQ 99, 107 (D.Del. 1966), *rev'd on other grounds*, 374 F.2d 473, 153 USPQ 1 (3rd Cir., 1967), *cert. denied*, 389 U.S. 826 (1967).

Indeed, § 1.56(a) of Title 37 of the Code of Federal Regulations, which has the full force and effect of law, recognizes the disadvantage of the examiner and imposes the following duty on all applicants for patents:

> A duty of candor and good faith toward the Patent and Trademark Office rests on the inventor, on each attorney or agent who prepares or prosecutes the application and on every other individual who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application. All such individuals have a duty to disclose the Office information they are aware of which is material to the examination of the application. Such information is material where

there is a substantial likelihood that a reasonable examiner would consider it important in deciding whether to allow the application to issue as a patent. The duty is commensurate with the degree of involvement in the preparation or prosecution of the application.

Where this standard has not been met, courts have found the applicant to have unclean hands and, in accordance with the principles of equity, have refused to enforce the patent. This standard is in harmony with the decisions of many courts that have dealt with this issue. *See*, for example, *Corning Glass Works, supra*; *SCM Corp.* v. *Radio Corp. of America*, 318 F.Supp. 433, 449, 167 USPQ 196, 207-08 (S.D.N.Y. 1970). As discussed previously, the disclosure of the McLean reissue adds nothing of significance to the disclosure of the original McLean patent. Although the examiner may have been interested in the McLean reissue, it is not a particularly relevant reference because the examiner had already thoroughly considered the disclosure of the original McLean patent. The withholding of the McLean reissue can hardly be considered the type of conduct which would lead to a holding of unenforceability. Accordingly, defendant has failed to prove that plaintiff has indulged in any inequitable conduct, and its contentions must be rejected.

Infringement

Plaintiff alleges that the following spacecraft systems, which have been used or manufactured by or

for the United States[20] after September 11, 1973 (the issue date of the Williams patent), infringe the claims of the Williams patent (U.S. Patent No. 3,758,051): Skynet II, NATO II, DSCS II, IMP (H and J), Solrad (9 and 10), and Pioneer (10 and 11). The defendant claims that none of the systems listed above infringe any of the claims of the Williams patent.

It is useful to divide these systems into two groups. The first group consists of Skynet II, NATO II, DSCS II, IMP (H and J), and the programmed mode of Pioneer (10 and 11). These systems will be referred to as "store and execute" (S/E) systems. The second group consists of Solrad (9 and 10) and the real time mode of Pioneer (10 and 11). These two systems will be referred to as "real time" systems. The reasons for these names will become apparent as the systems are described.

I have determined for reasons detailed below that none of the S/E systems infringe any of the claims of the Williams patent, and that both of the real time systems infringe the Williams patent.

The Store and Execute Systems

The store and execute systems have many elements that are similar, if not identical, to the system described in the Williams patent. Each of the systems includes (1) a spin-stabilized spacecraft; (2) means for

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[20] 28 U.S.C. § 1498 reads in pertinent part:

"Whenever an invention described in and covered by a patent of the United States is used or manufactured by or for the United States without license of the owner thereof or lawful right to use or manufacture the same, the owner's remedy shall be by action against the United States in the Court of Claims for the recovery of his reasonable and entire compensation for such use and manufacture."

determining the orientation of the spin axis of the spacecraft from the earth; (3) means for signaling from the earth to the spacecraft that a change in orientation is desired; (4) a precession jet mounted on the spacecraft offset from the spin axis; and (5) means for pulsing the offset jet in synchronism with the spin of the spacecraft so that the spin axis is precessed in the desired direction. The Williams system includes all of these elements. However, it is basic in patent law that the claims, not the patent disclosure, define the scope of invention. 35 U.S.C. § 112, second paragraph. No matter how fair or equitable it may seem, a court cannot rewrite the claims. *Autogiro Co. of America* v. *United States*, 181 Ct.Cl. 55, 60, 384 F.2d 391, 396, 155 USPQ 697, 701 (1967). As will be shown below, the claims of the Williams patent each call for at least two elements that cannot be found in any of the Skynet II, NATO II, and DSCS II systems, and at least one element that cannot be found in either the Solrad (9 and 10) system or the programmed mode of the Pioneer (10 and 11) system. Additionally, it will be shown that the doctrine of equivalents does not operate to expand the scope of the claims to cover these systems. Thus, the store and execute systems do not infringe the claims of the Williams patent.

Claim 1 of the Williams patent reads in pertinent part as follows:

> e. means disposed on said body for providing an indication to a location external to said body of the instantaneous spin angle position of said body about said axis and the orientation of said axis with reference to a fixed external coordinate system;

f. and means disposed on said body for receiving from said location control signals synchronized with said indication;

g. said valve being coupled to said last named means and responsive to said control signals for applying fluid to said fluid expulsion means in synchronism therewith for precessing said body to orient said axis in a predetermined desired relationship with said fixed external coordinate system.

Claims 2 and 3 claim substantially the same subject matter a little more narrowly. Due to the fact that I find no infringement, there is no need to consider these differences in connection with the store and execute systems.

The first step is to ascertain the meaning of the portion of claim 1 quoted above. As many cases have recognized, the written word is a valuable but imperfect conduit by which ideas may be conveyed. *Id.* at 61,384, F.2d at 396, 155 USPQ at 702. In determining what concepts the plaintiff intended to convey when it wrote the claim language, I am guided by (1) the specification, (2) the drawings, and (3) the file wrapper.

The instantaneous spin angle position (ISA) with respect to a fixed coordinate system has been defined in my previous consideration of a defendant's contention that the patent in suit was obvious. In order to understand what the ISA is, it is important to see what purpose this information serves. Application of the torque needed to precess the spinning spacecraft is provided by a jet offset from the spin axis. This jet is spinning with the spacecraft. In order to provide a torque in only one desired direction, the jet must be pulsed on for only a short time, *i.e.*, for less than an

entire revolution of the satellite, while it passes through the proper position. In order to pulse the jet at the desired time, the angle between the plane formed by the spin axis and a line from the jet to the center of the mass of the satellite (which plane is constantly rotating) and the reference plane formed by the spin axis and the sun vector (the line from the sun to the center of mass of the satellite) must be known for all instants of time. Thus, the instantaneous spin angle position in a fixed external coordinate system is a measure of where the precessing jet is in its cycle relative to a reference plane at any given instant of time. Because the spacecraft is always spinning, the ISA is a constantly changing value.

The claim requires only that an "indication" of the ISA be provided to an external location and not the ISA itself. The distinction between providing an "indication" of the ISA and providing the ISA itself is clear after gaining an understanding of the operation of the Williams system. In order to synchronize the precession jet commands sent from the earth controller with the spin of the Williams satellite, the ISA must be known on the ground. However, there is no need to send a constant series of angles (the ISA for any given instant) directly from the satellite. All that is needed is to send enough information from the satellite such that the instantaneous spin angle position can be determined for any given instant of time. Plaintiff recognized this and, as a result, decided to use the broader language "indication of the instantaneous spin angle position."

This interpretation, that "indication" of the ISA means enough information from which the ISA can be determined, is consistent with the requirements of the rest of the claim. Clauses (e), (f) and (g) of claim 1

require that (1) an indication of the ISA be provided to an external location; (2) that the spinning body have means for receiving control signals that are synchronized with the indication of the ISA; and (3) that fluid be applied to the fluid expulsion means (the precession jet) in response to the control signals so that the body is precessed in a predetermined direction.[21] It is clear that these elements come into play after the ground control has determined (1) the orientation of the spin axis of the body in a fixed external coordinate system; (2) the desired orientation of the spin axis; and (3) where during the spin angle the precession jet must be pulsed to precess the spin axis towards the desired orientation. Up to this point there is no need for the ground control to know what the ISA is. In the scheme of the claim, the ground control next will send a control signal synchronized with the particular point in the spin period during which the precession jet should be pulsed. The spinning body then has means for pulsing the precession jet in response to the control signal.

In order to permit the ground control to pulse the precession jet during the proper portion of the spin cycle, there must be a known fixed time period between the receipt of a control signal and the activation of the precession jet. In the exemplary embodiment disclosed in the Williams patent, the fixed time period is as close to zero as possible. The only delay is the time it takes the signal to travel through the electronic circuitry and the time it takes to actuate the valve.

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[21] Although other elements are claimed in this portion of the claim, these are the only elements that need be considered here.

Claim 1, then, calls for a spinning body having (1) means for providing information sufficient to determine the ISA to an external location and (2) means for pulsing the precession jet within a fixed time period after the receipt of a control signal from the remote location. Thus, even though the ground control itself is not an element of the claim, the structure called for on the spinning body limits the claim to an attitude control system wherein a ground controller is needed to determine the ISA and use it to pulse the precession jet during the desired portion of the spin cycle.

Skynet II, NATO II, DSCS II

The store and execute attitude control systems are different from the claimed system in that the ISA is used on board the spacecraft instead of on the ground to pulse the precession jet during the desired portion of the spin cycle. In the Skynet II, NATO II, and DSCS II systems, the satellite sends information to the earth control station from which the orientation of the spin axis of the satellite can be determined, as well as the spin rate of the satellite. However, there is no means on the satellite for providing the earth with enough information from which the ISA can be determined.

After determining the orientation of the satellite, the ground control decides whether a change is needed. If needed, the ground control formulates a command to operate the precession jet at a particular desired point in the spin cycle. Earth or sun sensors located on the satellite provide the needed synchronization pulses. Thus, the ground control, knowing the orientation of the satellite in a fixed external coordinate system and knowing the spin rate, determines how long after the synchronization pulse

the precession jet should be fired. This command is sent to and stored on board the satellite. This command information is then relayed back to the earth control station and compared with the original to be sure they are identical. Next, the control station sends the execute command. Upon receipt of this command, the satellite implements the original command by waiting until the next synchronization pulse and then firing the precession jet after the time specified in the original command has elapsed.

Claim 1 of Williams requires (1) means for providing an indication of the ISA to an external location, and (2) means for pulsing the precession jet within a fixed time period after the receipt of the control signal. Neither of these two claimed elements can be shown in the structure of the accused Skynet II, NATO II and DSCS II systems. Therefore, as claims 2 and 3 of Williams also include this subject matter, it is clear that the claims of Williams do not literally read on the structure of these satellites.

IMP (H and J), Pioneer (10 and 11)

IMP (H and J) and Pioneer (10 and 11) (the programmed mode) have attitude control systems that are very similar to those found in Skynet II, NATO II and DSCS II, described above. The significant difference for the purposes of this issue is that the IMP (H and J) and Pioneer (10 and 11) send information to the ground control from which the ISA could be determined. (See para. 10(e) of plaintiff's Rule 111 submission and defendant's response.) This information, however, is not used by the ground control for attitude control in either IMP (H and J) or the programmed mode of Pioneer (10 and 11). Apparently, it is used to aid in analyzing the scientific data. Thus,

in each of these systems the ground control sends a command to the spinning spacecraft indicating the direction in which the spacecraft is to be precessed. This command is stored in the spacecraft and relayed back so that ground control knows that the correct information has been stored. Ground control then sends an execute signal to the spacecraft. Using the synchronization pulse on the spacecraft, the original command is implemented by pulsing the precession jet during the proper portion of the spin cycle.

The claims of Williams require means for pulsing the precession jet within a *fixed time period* after receipt of the control signal. Neither the command nor the execute signal of these two systems operate to activate a precession jet within a fixed time period after the signal is received. Thus, even though an indication of the ISA is sent to an external location, the claims of Williams do not literally read on the accused IMP (H and J) system or the programmed mode of the Pioneer (10 and 11) system.

The Plaintiff's Arguments

Prior to the filing of the supplemental briefs, plaintiff had conceded that the claims of Williams did not literally read on the store and execute systems and that the only way the accused systems could be found to be infringing was by virtue of the doctrine of equivalents. On page 4 of plaintiff's posttrial reply brief, plaintiff states:

> The Government leads off * * * with a long argument addressed to a point not in dispute—namely, that the claims of the patent in suit do not literally "read" on the store-and-execute spacecraft. (Hughes has acknowledged that all along. * * *)

Plaintiff now (in the supplemental posttrial briefs) makes the contradictory argument that the claims do literally read on the accused store and execute spacecraft. Plaintiff goes on to make the rather surprising argument that plaintiff never admitted the claims did not read on the accused spacecraft. These arguments can be dismissed summarily.

First, it is clear from a reading of plaintiff's posttrial papers, including the remark quoted above, that plaintiff has already conceded that none of the claims literally read on any of the accused store and execute systems.

It is, of course, well known that an admission conclusively establishes, for purposes of the pending action, the matter admitted. While procedures exist to enable a party to withdraw its admission, plaintiff in this instance has not shown that it acted with due diligence to be relieved of the admission or that defendant would not be prejudiced by the withdrawal. Plaintiff's mere pronouncement of a contrary position in its supplemental posttrial briefs is hardly adequate to release it from its prior admission.

The only remaining question is how, if at all, the decision made by the court in *Hughes Aircraft Co.* v. *United States*, 226 Ct.Cl. __, 640 F.2d 1193, 208 USPQ 785 (1980), affects this issue.

The plaintiff claims that the findings of fact adopted by this court define the instantaneous spin angle position differently from the way defendant defined it in its proposed findings of fact. Defendant's definition,[22] which is equivalent to the definition I have used throughout this opinion, reads as follows:

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[22] Plaintiff in its objections to defendant's proposed findings agreed that this definition was "factually accurate."

> The instantaneous spin angle position of a spacecraft is an indication or representation of where the spacecraft is in its 360 degree spin cycle (rotation) about its spin axis (axis of rotation) at any given instant of time.

Plaintiff then points to finding of fact 35 (adopted by the court) and claims that the court's discussion of the ISA omits any requirement that the "indication of the ISA position be as of a 'given' or specified 'instant of time.'" Plaintiff's language, however, is confusing because "ISA" is the quantity being defined and there is no requirement that this quantity be as of a "given" or specified "instant of time." All that is needed to determine the ISA is to know the angular position of the body for any given instant of time. This information can be given in advance for future instants of time.

Plaintiff points to finding 35 as a definition of the ISA and then argues that a satellite which sends the spin rate to the ground controller (as all of the store and execute spacecraft do) meets the definition. This can only be viewed as an argument made in desperation. Finding 35, when read in the context of the other findings, and especially finding 41, simply does not support plaintiff's position. As should be clear by now, the spin rate is only one of the pieces of information needed to determine the ISA.

It will be recalled that the claims of Williams also require means for pulsing the precession jet within a fixed time period after the receipt of a control signal. Plaintiff admits that in Williams the jet is activated directly upon receipt of the control signal while in the store and execute systems the command signal is first stored and verified. The later execute signal in

the store and execute systems sets the original command into action but there is no fixed time interval between the receipt of the execute signal and the firing of the precession jet. No command signal is synchronized with the ISA. There is no structure on the store and execute spacecraft which acts to pulse the precession jet within a fixed time period after the receipt of a control signal. Plaintiff argues, however, that this difference—

> [I]s of no consequence because of the inert and benign characteristics of space, and there is no need for any immediate reaction to the occasional requirement of precession.

This comment, however, has nothing to do with the requirements of the Williams claims which plaintiff has conveniently chosen to ignore. It bears repeating that it is the claims which define the boundaries of the protected invention.

File Wrapper Estoppel and the Doctrine of Equivalents

As the claims of the Williams patent do not literally read on the store and execute systems, plaintiff's only argument is that the doctrine of equivalents acts to expand the scope of the claims to cover the accused systems. However, as will be seen below, this doctrine does not help plaintiff in this case.

The doctrine of equivalents acts to cast a penumbra around the literal claim language which must also be avoided if there is to be no infringement. *Autogiro Co. of America* v. *United States*, 181 Ct.Cl. 55, 66-67, 384 F.2d 391, 400, 155 USPQ 697, 704-05 (1967). In order to find equivalence and thus infringement, the court must find that the accused structure performs

substantially the same function in substantially the same way and for substantially the same purpose as set forth in the claims. *Id.* The rationale for the doctrine was set forth by the Supreme Court in *Graver Tank & Mfg. Co.* v. *Linde Air Products Co.*, 339 U.S. 605, 607 (1950):

> [T]o permit imitation of a patented invention which does not copy every literal detail would be to convert the protection of the patent grant to a hollow and useless thing. Such a limitation would leave room for—indeed encourage—the unscrupulous copyist to make unimportant and insubstantial changes and substitutions in the patent which, though adding nothing, would be enough to take the copied matter outside the claim, and hence outside the reach of law.

One of the guideposts used in determining the range of equivalents to be given is to determine whether the patent is a pioneer patent. As courts generally give pioneer patents wider ranges of equivalents than minor improvement patents, plaintiff's first argument in this area is to claim pioneer status for the Williams patent. *Autogiro Co.*, at 67,384 F.2d at 400, 155 USPQ at 705.

In *Westinghouse* v. *Boyden Power Brake Co.*, 170 U.S. 537, 61-62 (1898), the Supreme Court defined "pioneer" invention as follows:

> This word, although used somewhat loosely, is commonly understood to denote a patent covering a function never before performed, a wholly novel device, or one of such novelty and importance as to mark a distinct step in the progress of the art, as distinguished from a mere improvement or perfection of what has gone before.

In order to decide whether any of the three tests have been met, the Williams patent must be put in the context of the prior art. *Tate Engineering, Inc.* v. *United States*, 201 Ct.Cl. 711, 719-20, 477 F.2d 1336, 1340-41, 175 USPQ 115, 118, 178 USPQ 365 (1973).

Put another way, the Supreme Court in *Singer Mfg. Co.* v. *Cramer*, 192 U.S. 265, 277 (1904), when it was called upon to apply the test it previously had announced in Westinghouse stated:

> To ascertain whether the patented invention of Cramer is entitled to be embraced within the term pioneer as just defined [the Westinghouse definition], we will consider it in connection with the state of the art.

The prior art references which are relevant to my consideration of whether the Williams patent is a pioneer patent have all been discussed before. The Rosen-Williams patent (No. 3,396,920) filed December 30, 1959, and issued August 13, 1968, discloses a spin-stabilized satellite whose orientation is controlled by a ground controller. The orientation problem is solved in Rosen, et al., by stopping the spin, changing the spin axis orientation, and then starting the spin up again. The McLean patent (No. 3,216,674) filed June 8, 1959, and issued November 9, 1965, discloses a spin-stabilized, target-seeking vehicle. McLean used a precession jet offset from the spin axis and pulsed at the appropriate point in the spin cycle of the vehicle to change its orientation. Independent of McLean's work, Williams applied the pulsed precession jet concept of McLean to solve the orientation problem of the remote controlled satellite of the type disclosed by Rosen, et al. This was an important advance in the art and a patent was granted in recognition of this

contribution. However, in view of the above-referred to prior art, it is clear that this was not a pioneer invention.

Plaintiff argues that the Williams patent covers "a function never before performed." Although it is true that the space vehicle of McLean was never actually built and thus its disclosed function was never actually performed, I feel that in applying the *Westinghouse* test, any disclosure in a patent of a device and its associated function which satisfies the requirements of 35 U.S.C. §§ 101 and 112 should be considered. Thus, all of the functions covered by the claims of Williams have been performed before, either by the Rosen, et al., satellite or the McLean space vehicle. Also, it is clear from the prior art that the Williams satellite is not wholly novel. Finally, while it was an important step in the progress of the art, the Williams patent, when viewed in light of the very close prior art, cannot be considered to have reached the level of a pioneering invention.

Before examining whether the accused store-and-execute devices are the equivalent of the Williams claimed invention, the interaction of file wrapper estoppel with the doctrine of equivalents must be discussed.

In this case, the record clearly shows that plaintiff, during the prosecution, of the Williams patent application, performed certain acts that limited the range of equivalents to which the claims at bar are entitled. It is settled law that the doctrine of equivalents is subservient to file wrapper estoppel. *Autogiro Co.* at 67, 384 F.2d at 400, 155 USPQ at 705. The rationale behind file wrapper estoppel is that an applicant who has narrowed his claims in order to overcome prior art during the prosecution before the Patent Office

should not be permitted to recapture this subject matter during a later infringement action. As this court said, *id.* at 68, 384 F.2d at 401, 155 USPQ at 705:

> Thus a patent that has been severely limited to avoid the prior art will only have a small range between it and the point beyond which it violates file wrapper estoppel.

Just prior to the citation of McLean, the plaintiff still had claims 3, 5 and 8-14 in the case. These claims were directed broadly to controlled precession of a spinning body using an offset precession jet pulsed synchronously with the spin of the body. In response to the citation of McLean, plaintiff cancelled claims 3, 5 and 8-14 and added three new claims which are now patent claims 1-3. Each of these claims recited the two elements discussed above in connection with the distinctions between the store and execute systems and the Williams system. These elements had not been previously claimed in claims 3, 5 and 8-14.

The first element is the means for providing an indication of the ISA to an external location. Skynet II, NATO II and DSCS II do not have such a means. The second element is the means for applying fluid to said fluid expulsion means within a fixed time period after the receipt of a control signal. None of the accused store and execute spacecraft have such a means. These elements were added in combination with a number of other elements to overcome the prior art cited. While it may in hindsight appear that one or both of these elements would not have been needed to overcome the examiner's rejection, this is sheer speculation. There is no way of knowing how the examiner would have reacted to such omissions. As plaintiff included these elements in the claims to

overcome the prior art, plaintiff is now estopped from claiming that these elements are unnecessary to avoid the art.

As alluded to before, file wrapper estoppel acts to severely limit the range of equivalents to which a claim is entitled. It, however, does not eliminate all equivalents. The range of equivalents to which claims may be entitled after an estoppel has been previously discussed in *Eastern Rotorcraft Corp.* v. *United States*, 184 Ct.Cl. 709, 717, 397 F.2d 978, 982, 154 USPQ 43, 46, 158 USPQ 294 (1968), where this court said:

> The doctrine of file wrapper estoppel does not necessarily apply to the extent of depriving a patentee of all equivalents. Cancellation of a broad claim precludes an extension of claim coverage by equivalents to encompass the entire scope of the cancelled claim. However, the patentee after cancellation of a broad claim, is still to be afforded protection against obvious and exact equivalents.

In view of the file wrapper estoppel in this case, the doctrine of equivalents affords protection only against alleged infringers who use obvious and exact equivalents of the elements of the claimed invention. There is no obvious or exact equivalent of plaintiff's means for providing an indication of the ISA to an external location in either of the Skynet II, NATO II or DSCS II systems. Nor is there an obvious or exact equivalent of the means for pulsing the precession jet within a fixed time period after the receipt of a control signal in any of the accused store and execute systems.

For the reasons stated above, it is concluded that none of the accused store and execute systems (Sky-

net II, NATO II, DSCS II, IMP (H and J), and the programmed mode of Pioneer (10 and 11)) infringe any of the claims of the Williams patent.

The Real Time Systems

The remaining spacecraft systems, which plaintiff alleges infringe the claims of the Williams patent, are referred to, for convenience, as the "real time" systems. There are two real time systems, Solrad (9 and 10) and the real time mode of Pioneer (10 and 11). For the reasons detailed below, Solrad (9 and 10) and the real time mode of Pioneer (10 and 11) are found to infringe only claim 1 of the Williams patent.

Solrad (9 and 10)

The Solrad (9 and 10) satellites are equipped with an attitude control system capable of functioning in an automatic and a real time mode. Plaintiff makes no argument that the automatic mode infringes the claims of the Williams patent. However, in order to put the real time mode in context, it is important to consider how the automatic mode functions. The Solrad satellites were designed to be placed in orbit around the earth to monitor solar radiation. In order to do so, each of the two satellites was set up to constantly maintain a selected orientation with respect to the sun. Solrad 9's orientation kept its spin axis perpendicular to the sun vector (the line between the sun and the center of mass of the satellite) while Solrad 10 kept its spin axis directed at the sun.

In order to keep these satellites in their proper orientation, an automatic attitude control system was provided. This system included a precession jet disposed on the satellite such that it was spaced from the spin axis and oriented to expel gas substantially

along a line parallel to the spin axis. Sun sensors positioned on the satellite provided an indication of the ISA with respect to the sun and an indication of the sun angle (the angle between the spin axis and the sun vector). When the satellite deviated from its preferred orientation with respect to the sun (perpendicular for Solrad 9 and aligned for Solrad 10), the information provided by the sun sensors was automatically used to pulse the precession jet during the proper portion of the spin cycle so that the satellite was precessed back into its desired orientation.

In sum, since the automatic mode generates the signal to actuate the axially disposed precessing jet on the satellite, without any radio contact with an earth-based control station, it is clear that it does not infringe the Williams patent.

However, each of the Solrad (9 and 10) satellites, in addition to being equipped with an automatic operation mode, is also provided with a real time backup mode. The additional hardware for this mode consisted of a circuit which permitted the precession jet valve to be directly operated by a signal applied from the ground station. It is this so-called real time backup mode that plaintiff claims infringes the claims of Williams. The designers of Solrad (9 and 10) were concerned with the possibility of the failure of the satellites' sun sensors. The real time mode could then be used to provide the needed attitude adjustments from the ground using a fine angle sensor.

The fine angle sensor provided an indication of the instantaneous spin angle position and the angle of the spin axis with respect to the sun vector. This information was relayed to the ground. Normally, this was used to help in interpreting scientific data, but in the case of failure of other sun sensors, this information

could be used to determine when a signal to pulse the precession jet should be sent in order to restore the proper orientation.

Defendant points out that ground control has had at all times the capability of pulsing the jet directly from the ground. However, in order to send a pulse that will activate the jet at the proper time in the spin cycle, some equipment must be provided to do a job similar to that done by the apparatus of Fig. 12 of the Williams patent. Defendant stresses that since the automatic attitude correction system has never failed, the necessary equipment has never been built.

Defendant argues, even though this court found that the ground controller was not an element of the claims of Williams, that the claims still require a control pulse synchronized with the ISA. In view of this court's interpretation of the claims,[23] it is clear that there is no such requirement. The language in question is clause (f) of claim 1 (claims 2 and 3 have equivalent language) which calls for:

> [M]eans disposed on said body for receiving from said [external] location control signals synchronized with said indication [of the ISA]; * * *.

All that this phrase requires is some means on the body which is capable of receiving synchronized signals. There is nothing in the claim that requires synchronized signals to be provided.

This language, however, is not meaningless surplusage. Indeed, the reference in element (f) to the

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[23] As previously discussed, this court has found that "the claims of the patent cover solely the orbiting satellite and no other object, device, means, or apparatus." *Hughes Aircraft Co.* v. *United States*, 226 Ct.Cl. __, 640 F.2d 1193, 1195, 208 USPQ 785, 788 (1980).

control signals being synchronized with the indication of the ISA makes the function and structure of the elements that are specifically claimed clear. In view of this language, there can be no doubt regarding the type of remote control station that the claim spinning body is intended to interact with.

In order for defendant to be liable for the unauthorized taking of plaintiff's invention it is necessary to show that the Solrad 9 and 10 satellites were both made or used after the September 11, 1973, issue date of Williams. 28 U.S.C. §1498. Since there appears to be no question that both Solrad 9 and 10 were made before the issuance of the patent, it is necessary for plaintiff to show that these satellites were used during the relevant accounting period. *Coakwell* v. *United States*, 178 Ct.Cl. 654, 659, 372 F.2d 508, 511, 153 USPQ 307, 309 (1967), which deals with this very issue, clearly states:

> The fact that certain articles embodying an invention were manufactured before and obtained by the defendant before the patent was issued does not authorize their use thereafter.

It is clear, however, that defendant has used the claimed subject matter in the Solrad 9 and 10 satellites. The fact that the real time mode is used as a backup to the automatic mode and has never actually been put into operation does detract from this conclusion. Use of a system as a backup mode or to provide an extra measure of safety is "use" within the meaning of 28 U.S.C. § 1498. *Id.*; *Olsson* v. *United States*, 87 Ct.Cl. 642, 25 F.Supp. 495, 37 USPQ 767 (1938), *cert. denied*, 307 U.S. 621 (1939). Thus, the accused real time Solrad (9 and 10) control systems

have been used in accordance with the requirements of 28 U.S.C. §1498.

As will be shown below, the Solrad (9 and 10) real time systems include all of the elements of claim 1.

Claim 1 of Williams requires:

1. Apparatus comprising:

   a. a body adapted to spin about an axis; The Solrad satellites were spin stabilized. Additionally, claim 1 calls for:

   b. fluid supply means associated with said body;

   c. a valve connected to said fluid supply means;

   d. fluid expulsion means disposed on said body and coupled with said valve and oriented to expel said fluid substantially along a line parallel to said axis and separated therefrom; * * *.

The Solrad satellites each had a nozzle oriented parallel to the spin axis and connected through a valve to a tank of gas.

Clause (e) of claim 1 requires:

   e. means disposed on said body for providing an indication to a location external to said body of the instantaneous spin angle position of said body about said axis and the orientation of said axis with reference to a fixed external coordinate system; * * *.

The Solrad satellites each provided an indication of the ISA with respect to the sun (previously assumed to be a fixed point in a fixed external coordinate sys-

tem) to the ground control for purposes of processing the scientific data. This ISA indication was provided by a fine angle sensor independently of the sun sensors used for the automatic orientation mode. It was contemplated that if the orientation sun sensors failed that the ISA used for the experiments could have been used to provide the needed synchronization to operate in the real time mode. The Solrad satellites also provided an indication of the orientation of the spin axis in a fixed external coordinate system.

Finally, claim 1 requires:

> f. and means disposed on said body for receiving from said location control signals synchronized with said indication;
>
> g. said valve being coupled to said last named means and responsive to said control signals for applying fluid to said fluid expulsion means in synchronism therewith for precessing said body to orient said axis in a predetermined desired relationship with said fixed external coordinate system.

Both Solrad satellites had a circuit which permitted the precession jet valve to be directly operated by a signal from ground control. Thus, as all of the elements of the claim have been shown in the Solrad (9 and 10) systems, claim 1 is infringed.

Claims 2 and 3 of Williams incorporate substantially all of the subject matter of claim 1 along with some additional limitations. The significant added limitations are that claim 2 requires "wide angle means" and claim 3 requires "wide angle optical

means" for providing the ISA and orientation indications.

Plaintiff has the burden of proof on the issue of infringement. *Roberts Dairy Co.* v. *United States*, 208 Ct.Cl. 830, 851, 530 F.2d 1342, 1357, 182 USPQ 218, 227, 198 USPQ 383 (1976). Plaintiff, however, has never set forth all of the elements of the claims and pointed out where each of the elements can be found in the accused structure. In the case of Solrad (9 and 10), plaintiff is apparently attempting to put the burden on the defendant to show that these satellites do not infringe. On page 33 of plaintiff's posttrial brief, plaintiff makes the conclusory statement that:

> SOLRAD's * * * "real time" mode, was designed to operate in faithful conformity to the Williams teaching.

The record cited for this proposition supports only a statement that the Solrad's real time mode is intended to be operated in a manner very similar to the operation of the Williams satellite. There is, however, no comparison of the claims with the structure of Solrad nor any showing that the Solrad real time mode was intended to be operated in "faithful conformity" to the Williams patent in any of the citations. On page 43 of the same brief, the plaintiff refers to the above-quoted assertion and states that the Government does not deny it.

The fact that the government has not denied it does not mean defendant had admitted that the Solrad satellites operate in faithful conformity to the teachings of the Williams patent. Plaintiff is still required to make a prima facie case.

Although plaintiff has produced sufficient evidence to show infringement of claim 1, plaintiff has failed to

meet its burden with respect to claims 2 and 3. These claims required wide angle means for providing the ISA and orientation indications. While each of the Solrad satellites had wide angle optical sensors, there is no indication from the record that these wide angle sensors were intended to be or could be used to provide indications of the ISA and orientation in a real time backup mode.

The fine angle sensor, intended to be used in the real time backup mode, had a field of view of about 10 degrees. Although the term "wide angle" does not provide a definite cutoff, it is clear from plaintiff's *ante litem motam* arguments, made in distiguishing McLean on this basis, that a 10 degrees field of view is not a wide angle field of view.[24]

Plaintiff has not pointed to any other element in the Solrad (9 and 10) satellites which meets the requirement of claims 2 and 3 for wide angle means which provide an indication of the ISA and orientation to a location external to the satellites. Nor has plaintiff pointed to any structure of the Solrad satellites which is the equivalent of the claimed means. Thus, the Solrad (9 and 10) satellites do not infringe claims 2 and 3 of the Williams patent.

The Real Time Mode of Pioneer (10 and 11)

Pioneer (10 and 11), unlike the other accused spacecraft, are not satellites. These spacecraft were designed to explore our solar system and in particular to investigate the interplanetary medium, the nature of the Asteroid Belt, and the environmental and at-

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[24] Plaintiff argued that the 8-10 degrees field of view of the sensor of McLean was not a wide angle field of view in the sense of the claims.

mospheric characteristics of the planet Jupiter. For the purposes of this case, the two spacecraft (Pioneer 10 and 11) can be considered as being identical. Hereinafter, a reference to "Pioneer" includes both spacecraft.

Like all the other accused spacecraft, Pioneer is spin stabilized. Pioneer has three attitude control modes: automatic, programmed precession, and real time. All of these modes use a precession jet offset from the spin axis and pulsed at the appropriate time of the spin cycle in order to change orientation. The automatic mode is called "Conscan" (conical scan), and acts to maintain the spin axis pointed in the direction of an r.f. (radio frequency) signal emanating from the earth. This automatic mode is similar to the automatic attitude control system of the McLean patent in that both act to automatically align the spin axis with a target. The plaintiff makes no argument that this mode infringes any of the claims of Williams.

The programmed mode was discussed in the store and execute section of this opinion and is very similar to the Skynet II, NATO II and DSCS II systems. This mode is used where it is necessary to make a course and/or velocity correction. The precise direction in which the onboard rocket must be fired is determined on the ground. The store and execute (programmed) mode is then used to orient the spacecraft so that the rocket points in the proper direction. The correction is made by firing the rocket for a predetermined period and then the spacecraft is returned to the automatic earth pointing mode. It has previously been determined that this mode does not infringe any of the claims of Williams.

The real time mode was designed as a backup system to be used in case of failure of one or more of the

primary attitude control systems. Like Solrad, this system includes a circuit which can be activated by a signal from the ground. Upon receipt of the signal, the precession jet is immediately pulsed. There has never been a need to use this backup circuit. It is clear, however, that a number of different uses were contemplated based on the various possible failures that could be envisioned. At least one of these contemplated modes of uses involved determining the ISA and orientation of the spacecraft with respect to a fixed external coordinate system on the ground from indications provided by the spacecraft.

In order to properly precess the spacecraft in this mode, the signal sent to activate the precession jet circuit must be sent in synchronism with the ISA. In order to do this, the ground control must be provided with equipment capable of performing the synchronizing function. (*See*, for example, Fig. 12 of Williams.) This equipment has never been built because the primary systems have all continued to function properly. As decided previously in connection with Solrad, however, the fact that the ground control equipment has never been built does not act to relieve defendant of infringement.

First, in view of this court's earlier opinion, there is no requirement in any of the claims that a control signal synchronized with the ISA be provided. Only the capability to receive such a signal is claimed. Secondly, use as a backup system is use in accordance with the requirements of 28 U.S.C. § 1498. *Coakwell* v. *United States*, 178 Ct.Cl. 654, 372 F.2d 508, 153 USPQ 307 (1967); *Olsson* v. *United States*, 87 Ct.Cl. 642, 25 F.Supp. 495, 37 USPQ 767 (1938), *cert. denied*, 307 U.S. 621 (1939).

As will now be shown, each element of claim 1 of Williams can be found in the Pioneer spacecraft.

Claim 1 of Williams calls for:

1. Apparatus comprising:

   a. a body adapted to spin about an axis; * * *. The Pioneer spacecraft is spin stabilized. In addition, the claim also requires:

   b. fluid supply means associated with said body;

   c. a valve connected to said fluid supply means;

   d. fluid expulsion means disposed on said body and coupled with said valve and oriented to expel said fluid substantially along a line parallel to said axis and separated therefrom; * * *.

Pioneer has a nozzle oriented parallel to the spin axis and connected through a valve to a gas supply tank.

Clause (e) of the claim provides:

   e. means disposed on said body for providing an indication to a location external to said body of the instantaneous spin angle position of said body about said axis and the orientation of said axis with reference to a fixed external coordinate system.

Pioneer's sun sensor provides an indication to ground control of the ISA with respect to the sun. The orientation of the spin axis with respect to a

fixed coordinate system can be determined from the telemetered Conscan phase and amplitude data. The Conscan system uses a medium gain directional antenna, offset from the spin axis by about 9.3 degrees. As the r.f. (radio frequency) signal from earth is received by the antenna, the Conscan system generates amplitude and phase data which is relayed to earth. This data indicates the degree to which the spin axis is out of alignment with the earth. When this data indicates that the spin axis is pointing at the earth, the orientation of the spin axis in a fixed coordinate system is known.

The Pioneer Program Document No. PC202 suggests on p. 5-3 that even if the Conscan function fails the Conscan telemetry of phase and amplitude data might remain. If, however, the Conscan telemetry has failed as well, document No. PC202 suggests that the orientation can be determined by dead reckoning using the time that Conscan last indicated that the spin axis was pointing at the earth, the rate of change of orientation in inertial space of the spacecraft-earth line, and the magnitude and direction of solar torques acting on the spacecraft.

Finally, claim 1 calls for:

> f. and means disposed on said body for receiving from said location control signals synchronized with said indication;
>
> g. said valve being coupled to said last-named means and responsive to said control signals for applying fluid to said fluid expulsion means in synchronism therewith for precessing said body to

orient said axis in a predetermined desired relationship with said fixed external coordinate system.

The Pioneer spacecraft each have a circuit which acts to pulse the precession jet immediately upon receipt of a control signal. Thus, as all of the elements of the claim have been shown in the Pioneer (10 and 11) real time system, claim 1 is infringed.

Claims 2 and 3 of Williams incorporate substantially all of the subject matter of claim 1 along with some additional limitations. The significant added limitations are that claim 2 requires "wide angle means" and claim 3 requires "wide angel optical means" for providing the ISA and orientation indications. Pioneer's sun sensor covers a field of view of 170 degrees. This is clearly wide angle and optical. However, this sensor provides no indication of the sun angle (the angle between the spin axis and the line from the sun to the spacecraft).

The orientation is determined by the medium gain Conscan antenna. This antenna determines pointing errors of about 10 degrees. The "field of view" of this antenna then is about 20 degrees. Although the term "wide angle" does not provide a clear cutoff, some guidance on the question of how wide the angle must be can be obtained from plaintiff's ante litem motam arguments made in distinguishing McLean on this basis. The field of view of the sensor of McLean is about 8 degrees to 10 degrees. Plaintiff argued that this is not a wide angle in the sense of the claims, pointing out that the solar sensor of Williams has a field of view of 140 degrees. Although it is still not clear where the cutoff between the wide angle and

narrow or medium angles is, it is clear that 20 degrees is not a wide angle field of view.

Plaintiff has not pointed to any other element which meets the requirement of claims 2 and 3 for wide angle means which provide an indication of the orientation of the spin axis. Nor has plaintiff pointed to any structure of Pioneer which is the equivalent of the claimed element. Thus, Pioneer (10 and 11) does not infringe claims 2 and 3 of the Williams patent.

Conclusion

For the reason detailed above, it is found that claims 1, 2 and 3 of United States Letters Patent No. 3,758,051 are valid and enforceable. Further, it is found that the accused Solrad (9 and 10) and Pioneer (10 and 11) systems have been used and/or manufactured by or for the defendant without authorization or license from the plaintiff and infringe claim 1. Claims 2 and 3 are not infringed by the Solrad (9 and 10) or Pioneer (10 and 11) systems. Claims 1, 2 and 3 are not infringed by any of the accused Skynet II, NATO II, DSCS II, or IMP (H and J) systems.

FINDINGS OF FACT

1. This is a patent suit arising under the provisions of 28 U.S.C. § 1498 for reasonable and entire compensation for the unauthorized procurement and/or use by the United States of an invention described and claimed in United States Letters Patent No. 3,758,051 (hereinafter referred to as the "Williams" or "051" patent), entitled "Velocity Control and Orientation of a Spin-Stabilized Body." The patent issued on September 11, 1973, to Donald D. Williams on application Serial No. 391,187, which was filed on August 21, 1964.

2. The Williams patent relates to a general attitude control system (hereinafter "ACS") for spacecraft, that was first used in SYNCOM II and SYNCOM III. SYNCOM II was the world's first synchronous communications satellite. SYNCOM III was the world's first geostationary communications satellite.

3. The question of liability is now before the court. A determination of the amount of recovery, if any, has been deferred until after a final ruling by this court on the issue of liability.

4. Williams' application Serial No. 391,187, was a continuation-in-part of a prior co-pending application, Serial No. 22,733, which was filed on April 18, 1960, and was later abandoned.

5. A general ACS is one capable of orienting or maintaining a body in any geometrically conceivable attitude while retaining full reorientation capability (*i.e.*, a change of purpose capability).

6. A synchronous satellite is one whose orbital period is equal to the rotational period of the earth. A geostationary satellite is a synchronous satellite whose orbit lies in the equatorial plane of the earth.

7. In 1945, Arthur C. Clarke suggested that three geostationary radio communications satellites be placed into orbit so as to provide complete radio coverage for the entire world. In 1957, SPUTNIK became the world's first artificial satellite. SYNCOM II and III were launched by NASA in 1963-64.

8.A radio communication satellite must be placed in a west-to-east circular orbit in the earth's equatorial plane, and have a period of 24 hours. In order to "hover" above a single point on earth, the satellite must be placed in an orbit having a 22,750-nautical-mile radius from the center of the earth and travel around the orbit at a linear velocity of 10,090 ft. per second.

9. To economize on power and weight, communications satellites are equipped with directional antennas. Such satellites can communicate with the earth only when the satellite is oriented so that the directional beam emitted by its antenna can strike the earth.

10. A communications satellite may also be provided with solar cells as a source of power. The efficient use of these cells requires that the satellite be oriented so that the cells are bathed in solar radiation as much of the time as possible.

11. A multistage rocket is typically used to convey communications satellites into a synchronous orbit. The various rocket stages are usually spin stabilized by use of jet vanes, spin nozzles, or spin rockets. As a

result, when the satellite is finally released, it too will be spinning, with its spin axis lying in its orbital plane.

12. This is the least desirable orientation for a communications satellite. By way of example, imagine a geostationary communications satellite spun about its antenna axis. Because of the spin stabilization, the orientation of the spin axis with respect to the stars will not change as the satellite orbits the earth. Imagine that the satellite has a directional antenna that emits a beam which is strong in the direction perpendicular to the spin axis, but weak at other angles. This type of beam is often referred to as a pancake-shaped beam. If the satellite's spin axis lies in its orbital plane (*i.e.*, the equatorial plane of the earth), its beam will strike the earth only twice each orbit, for a short time interval each time. (Remember that the orbital radius of a satellite in geostationary orbit is considerably greater than the radius of the earth.) On the other hand, if its spin axis is parallel to the earth's axis, its beam will strike the earth throughout its orbital period.

13. The most desirable orientation for a spinning communications satellite is such that its spin axis is perpendicular to its orbital plane.

14. Satellite orientation may be disturbed by solar radiation or by magnetic fields. For example, if the centroid of the solar radiation pressure is offset from the center of gravity of the satellite, a torque will result, and the attitude of the satellite will change in response thereto.

15. A communications satellite must therefore be equipped with an ACS which will enable it to precess and hold its spin axis into the desired orientation.

16. A suitable ACS must of necessity be light in weight, or the weight saved by using a directional antenna would be added back in the form of elaborate stabilizing equipment (*e.g.*, three axis gyro-and-rocket attitude control systems).

17. Following the successful launching in October 1957 by Russia of SPUTNIK, the world's first artificial satellite, the United States accelerated its efforts in space technology. One of the United States' earliest programs involved Project ADVENT, a communications satellite which was to be placed in geostationary orbit.

Project ADVENT was under the jurisdiction of the Department of Defense. It was to be part of a military satellite communications system which had to encode and decode its own messages and resist jamming by the enemy.

In addition, the ADVENT satellite was not spin-stabilized and thus its ACS was relatively heavy and complex. As a result, the weight of the ADVENT satellite was beyond the launching capability of existing rocket launch vehicles.

18. The orientation of a spinning body is not affected by the translational motion of the body. It is affected only by torques, which are forces applied to the body which do not act through its center of mass. A spinning body will reorient its spin axis if a torque is applied to it. The process of reorientation is known as precession. The spinning body is acting as a gyroscope. The principles of gyroscopic precession,

including knowledge of how to predict the amount and direction of precession of a gyroscope for a given appplied torque and a given angular momentum was well known at the time of Donald D. Williams' invention. In the absence of an external torque, a satellite spun-up so that its spin axis points toward Polaris, for example, will remain oriented toward Polaris, despite its orbital motion.

19. The advantages of spin-stabilizing a satellite were set forth by two Hughes Aircraft Company employees, Harold A. Rosen and Donald D. Williams, in United States Patent No. 3,396,920, "Apparatus for Changing the Orientation and Velocity of a Spinning Body Traversing a Path" (filed December 30, 1959; issued August 13, 1968). The patent explained that "(b)y using simple spin-stabilization to orient * * * [a] satellite, the weight and complexity of the satellite * * * [can be] minimized."

20. Rosen, *et al.*, taught a crude system for changing the orientation of a satellite. The spin about the old axis was halted by one set of tangential jets and the satellite was then "spun-up" around a new axis. The versatility of this ACS was limited by the number of sets of spin jets the satellite carried.

21. With this in mind, Dr. Rosen and Mr. Williams considered a different approach toward changing the orientation of the satellite's spin axis. The satellite was to be equipped with four precessing jets, spaced evenly near the outer periphery of the satellite. These jets were placed so as to fire parallel to, but offset from, the satellite's spin axis. Each jet would be pulsed when the satellite's rotation brought it to the proper spot. Soon thereafter, Mr. Williams estab-

lished that only a single precessing jet was required to precess the axis toward the desired orientation.

22. The reaction of a spinning body to an applied torque is somewhat counterintuitive. Imagine a spinning disk oriented so that its spin axis is vertical. Let the top face of the disk be marked off like a clock face. Apply an upward force to the rim of the disk at the point marked 9 o'clock. The spin axis of the disk will precess toward 6 o'clock if the disk is rotating clockwise and toward 12 o'clock if it is rotating counterclockwise. Thus, the time the spinning satellite's precessing jet is fired will determine the direction of precession.

23. The first written description of the Williams invention appeared in a January 1960 confidential report on the status of Hughes' Commercial Communication Satellite (COMSAT). This report discusses a spin-stabilized satellite equipped with a directional antenna, a V-beam sun sensor (described below), and a ground-commandable precessing jet.

24. The Hughes management was unwilling to go forward with the Rosen and Williams proposal—a Rosen spin-stabilized satellite equipped with a Williams ACS—without Government support of some kind. NASA was approached in early 1960.

25. Initially, the NASA response was discouraging. While the proposed Hughes satellite was expected to weigh a mere 25 lbs., American booster technology was still in a primitive state: "No booster existed that could put even a 25-pound satellite into a synchronous orbit."

26. On April 18, 1960, Mr. Williams applied for the patent now in suit.

27. In mid-1960, NASA and the Department of Defense decided to establish a joint synchronous satellite communications system, Project SYNCOM.

28. By mid-1960, improved boosters made feasible the injection of a lightweight (less than 100 lbs.) satellite into synchronous orbit.

29. In August 1961 the Goddard Space Center reported to NASA headquarters that the Hughes ACS was lighter and more reliable than systems employing heavy reaction wheels, gyros, and on-board attitude computers. Acting on the recommendation of the Center, Hughes was designated the sole source for the SYNCOM satellite. The sole source designation was justified, in NASA judgment, by the fact that Hughes "submitted the only proposal to NASA indicating that a 24-hour lightweight synchronous satellite having two-way voice communication capability is practicable."

30. The SYNCOM contract between Hughes and NASA was formally executed in August 1961.

31. Williams purports to describe a method and apparatus for controlling the orientation of the spin axis of a spin-stabilized space vehicle. These space vehicles, according to the patent, might include meteorological, astronomical, navigation and communications satellites, space probes and target-seeking vehicles.

32. Williams discloses a single embodiment of the claimed invention, a cylindrical earth-orbiting, spin-stabilized radio communications satellite.

33. In order to "steer" the satellite into a desired orientation, a means for sensing the attitude of its spin axis is provided. In the disclosed embodiment, a

V-beam sun sensor, composed of two slits 70 and 72 and two solar cells 71 and 73, is used. During each revolution of the satellite this sun sensor generates two electrical pulses (*see* finding 38) which, when received at the earth 100, provide a complete indication of the "instantaneous spin angle position" (*see* finding 34) of the satellite about its axis, and a partial indication (*see* findings 41) of the axis' orientation with respect to a "fixed external coordinate system" (*see* finding 37). Also disposed on the skin of the satellite is an antenna 50, whose axis coincides with the spin axis of the satellite. If "asymmetry is deliberately introduced into the antenna radiation pattern," the antenna may, according to the patent, be used to sense the orientation of the satellite. (More accurately, the strength and polarization of its signals, as received by the earth, will be indicative of the orientation of the axis.) (*See* col. 11, lines 9-15, of the Williams patent, an findings 43 and 44.)

34. The instantaneous spin angle position ("ISA") is a measure of where the satellite is in its spin cycle at any given instant of time. An ISA can be given for any fixed position on the rim of the vehicle (*e.g.*, the sun sensor, or the precessing jet nozzle referred to in finding 21) relative to a reference plane (*e.g.*, the plane determined by the spin axis of the satellite, and the sun line). The ISA is known when the angle between the reference plane and the selected fixed position on the rim of the vehicle is known for any given instant of time. Because the Williams satellite is spinning, the ISA is a constnatly changing value.

35. The sun line (or sun vector) is a line drawn between the center of mass of the satellite and the

sun. The earth line (or earth vector) is a line drawn between the satellite and the earth.

36. The sun angle is the angle between the spin axis and the sun line. The earth angle is the angle between the spin axis and the earth line.

37. A fixed external coordinate system is one fixed with respect to the distant stars, *i.e.*, one in which star coordinates do not change.

38. It is now appropriate to more fully describe the V-beam attitude sensor. Two slits, a vertical slit and a canted slit, are disposed on the cylindrical surface of the satellite. As the satellite rotates, the vertical slit will pass the sun line and the sun's rays will pass through the slit and strike a solar cell, generating an electrical signal. This signal is then transmitted to ground control through a first oscillator which modulates the radio transmission. As the satellite continues its rotation, the rays will pass through the canted slit, giving rise to a second electrical signal (the "slant pulse"). This second signal is then transmitted to ground control through a second oscillator which modulates (presumably at a different frequency than the first oscillator) the radio transmission. The optical field of view of the V-beam sensor is about 140 degrees centered about a line perpendicular to the spin axis. Because the sun emits such a large amount of radiation, the chance of confusing the sun signal with other lower level radiation emitting objects is negligible.

39. The interval between successive sun pulses provides an indication of the spin velocity of the satellite, and the time elapsed since the last sun pulse

thus provides an indication of the instantaneous spin angle position of the satellite about its axis.

40. An operator on the ground also uses the sun pulse information to determine the sun angle. Since the angle of inclination of the canted slit with respect to the vertical slit is known, and the spin velocity of the satellite is determinable, the interval between successive sun and slant pulses provides an indication of the angle between the satellite spin axis and the sun line (the sun angle), assuming that the sun angle is small enough so that the sun will pass through the fields of view of both sensors. As the slits are disposed so that they converge as they approach the base of the satellite, the interval is small when the sun is below the satellite equator and large when the sun is above the satellite equator. This sun angle is a partial indication (*see* finding 41) of the attitude of the satellite's axis.

41. To provide the capability for controlled changes in attitude to a variety of orientations in a fixed external coordinate system, there must be means provided for monitoring the orientation of the satellite within a fixed external coordinate system from the ground.

A single sun angle measurement, taken alone, does not provide enough information for a determination of the orientation of the spin axis of a spinning body with respect to a fixed external coordinate system. The spin axis may lie anywhere within a "cone of ambiguity." This may be illustrated with the aid of a pair of scissors. Call the long blade the sun line and the short blade the spin axis. The angle between the blades is the sun angle. The scissors may be rotated about the long blade, so that the short blade assumes a

variety of orientations, without changing the angle between the blades. As the scissors are rotated, the short blade describes what a mathematician would call a cone of revolution, and what in this case is referred to as the cone of ambiguity. In the trial judge's findings, adopted by the court in *Hughes Aircraft Co.* v. *United States*, 226 Ct.Cl. ____, 640 F.2d 1193, 208 USPQ 785 (1980), a list of ways in which this cone of ambiguity could be resovled was presented. The court found that the existence of the cone of ambiguity and each of the listed techniques for overcoming it would have been obvious to one of ordinary skill in the art. For this reason the original Williams disclosure supports claims which require means for indicating the orientation of the spin axis in a fixed external coordinate system. The following five findings briefly review these methods.

42. This ambiguity could be resolved by equipping the satellite with an earth sensor. The earth sensor would yield an earth angle, and a second cone of ambiguity. As the spin axis of the satellite would have to lie on both cones, it could only have one of two possible orientations (the two intersections of the cones). Since it may be difficult to visualize this, an analogy may be helpful. Let us say that a ship determines that it is 100 mi. from New York. If so, the navigator can draw a circle with a 100-mi. radius around New York on a map, and he will know that his ship is located on the circle. If he additionally knows that his ship is 300 mi. from Boston, he can draw a circle with a 300-mi. radius around Boston, and he will know that his ship must be located at one of the two intersections of the two circles. By the application of dead reckoning (*see* finding 45), one of the two

intersections is eliminated and the ship's location established.

43. One possible earth sensor would be the antenna. The antenna gain of a satellite-mounted directional antenna varies depending upon its orientation with respect to the earth. The magnitude and timing of the variation in signal strength could be used in the determination of the earth angle.

44. The polarization of the signal received could also be used to determine the earth angle.

45. Alternately, the ground controller of the satellite can take advantage of his knowledge of the initial orientation of the satellite. It is clear from the patent specification and from the testimony that when the satellite is injected into synchronous orbit its spin axis lies in the orbital plane. The orbital plane and the sun angle can therefore be used to fix the initial orientation of the satellite. If the precessing jet was precalibrated, *i.e.*, you knew what degree of precession would be induced by a given-duration pulse, the satellite could be steered into the desired orientation by dead reckoning, as the time at which to fire each pulse would be known.

46. Instead of determining both a sun angle and an earth angle, the orientation of the satellite in the patented system could be determined from progressive sun angle measurements. By way of analogy, defendant's DSCS series satellites achieve unambiguous attitude determinations by means of a single sensor, an earth sensor, coupled with progressive observations spaced at the quarter marks in its earth orbit. In principle, the same kind of unambiguous attitude determination could be made with a sun

sensor, coupled with progressive observations spaced at the quarter marks in its orbit around the sun. There are problems, however, associated with this orientation technique. The satellite attitude is likely to change as the satellite orbits the sun, and adjustments in attitude would be quite time-consuming.

47. Returning to the description of the disclosed embodiment, the V-beam sensor data and other satellite transmissions are received at a satellite ground-based control point and used to calculate the orientation (and the instantaneous spin angle position "ISA") of the satellite.

48. The calculated orientation would then be compared with the desired orientation, and a "course" for proceeding from one orientation to another would be calculated.

The attitude of the satellite is changed in response to external control signals, the latter being synchronized with the spin cycle of the satellite (*see* finding 53). The satellite is equipped with pressure tanks 53 which supply fluid to an attitude control valve 55. When the valve is opened in response to the control signal, the fluid is expelled through a nozzle 57. (The tank-valve-nozzle system will be referred to, on occasion, as the precessing jet). The nozzle is disposed and oriented so as to expel the fluid along a line substantially parallel to the satellite's spin axis and separated therefrom. If the fluid is expelled only during a predetermined portion of a spin cycle of the satellite—as determined by the synchronism of the control signals with the satellite's spin cycle (*see* finding 49)—the satellite will be precessed in the desired direction.

49. Figures 8 through 11 of the patent illustrate a simple attitude correction maneuver. Figure 8 shows the satellite spinning counterclockwise with its spin axis perpendicular to the earth's spin axis and the axial jet at 9 o'clock (the top of the page being 12 o'clock). The jet is pulsing, and the indicated direction of precession is toward 12 o'clock. (*See* finding 22.)

Figure 9 shows the spinning satellite, its axis somewhat precessed from its original position, and its axial jet, now silent, in the 6 o'clock position.

Figure 10 shows the satellite again, this time with its axial jet in the 9 o'clock position once more. The jet is pulsing, and again the satellite's direction of precession is toward 12 o'clock.

Figure 11 shows the spinning satellite, its axis now fully precessed into an orientation parallel to the earth's axis.

50. The factor which controls the direction of precession is thus the position of the jet at the time the attitude control valve is opened.

51. The precessing jet is enabled as soon as the control signal is received at the satellite though, of course, there is a momentary delay before the solenoid-controlled valve is opened and the gas is expelled.

52. Thus, ultimately, the direction of precession is controlled by the timing of the control signals which must take into account the transmission propagation delays and valve actuation delays.

53. In Fig. 12 and the associated text, the Williams specification purports to disclose an example of a ground-based analog control system that can be used to determine the times at which jet-actuating signals

are to be transmitted to a satellite. An analog control system is one in which a control element (*e.g.*, a rotating cam) behaves in some important respect (*e.g.*, speed and phase of rotation) just like the subject (*e.g.*, a satellite). The most important elements shown in Fig. 12 are a single lobe rotating cam, a fixed cam-controlled switch, a movable cam-controlled switch, and a motor to drive the cam. The speed of the motor driving the cam is adjusted to synchronize the rotating cam with the spinning satellite. Adjustments are made until the fixed switch is actuated at the same time as the sun pulse, or other spin angle reference signal, is received on the ground. Upon achieving this, the drum has been synchronized with the spin of the orbiting satellite.

54. When the movable switch is closed, the control signal is then sent up to the satellite.

55. If there were no delays between the broadcasting of the control signal and the opening of the valve, and the valve actuating pulse could be of high intensity and brief duration, matters would be simpler. By way of example, assume that the satellite was spinning at a rate of 1 r.p.s., and that the thruster was one-quarter of the way around the satellite rim from the V-beam sensor. If the thruster were pulsed one-quarter of a second after the sun pulse, its ISA at the time of pulse would be zero (*i.e.*, it would lie on the sun line), and the direction of precession would be perpendicular to the sun line.

56. Since a narrow pulse is not feasible, the thruster might be opened one-sixth of a second after the sun pulse and closed one-third of a second after the sun pulse and the net result would be that the thruster is actuated symmetrically about its zero

ISA so that the net effect would be as described in the example of finding 76.

57. But now assume that the sun pulse takes one-tenth of a second to reach the earth and the control signal takes one-tenth of a second to reach the satellite, and that there is a further delay of one second in the satellite electronics and mechanisms. If so, the control signal must be sent up one-fifth of a second after the sun pulse is received. This is equivalent to saying that the movable switch must be positioned 288 degrees away from the fixed switch.

Patent and Trademark Office Proceedings

58. The Williams parent application was filed in the Patent and Trademark Office on April 18, 1960, and was accorded Serial No. 22,733. It contained essentially the same Figs. 1-11 and their accompanying descriptions as are found in the patent in suit. It did not contain either Fig. 12 nor its corresponding description, as found at col. 9, line 14, to col. 10, line 50, of the patent in suit.

59. The 1960 application presented nine claims to the Patent and Trademark Office for consideration by the examiner. As an aid to understanding the examiner's position in later actions, the language of original claim 2 is instructive. Claim 2 claimed a body with a spin axis, a source of pressurized gas, a jet disposed on the body parallel to and spaced from the spin axis, a controllable valve connecting the gas to the jet, and "control means coupled to said valve for actuating said valve in pulses synchronized with the spin of said body." Comparing this claim language with the example disclosed by the application, it is clear that the "control means" necessarily includes

the remote control system, including some sort of ground controller. This is because, as disclosed, the remote control system is an indispensable link in the loop providing the synchronization between the sensing of the spin angle position of the body and the pulsing of the jet valve needed for controlled precession. The examiner at the Patent and Trademark Office before whom the application was pending, made no objection to claim 2 under 35 U.S.C. § 112, first paragraph. This amounts to a determination by the examiner that claim 2, including a broad recitation of ground controller, was properly supported by the original disclosure.

60. The examiner in the first office action allowed claims 1-5, 7 and 8, and rejected claims 6 and 9. In response, plaintiff cancelled claims 6 and 9, and added claims 10-14. In the second office action, the examiner cited new art and rejected claims 1, 2 and 10-14, while repeating the allowance of claims 3-5, 7 and 8. In response, plaintiff cancelled claims 1, 2 and 10-14 and filed new claims 15-19. The new claims, in applicant's own words, "are drawn to applicant's apparatus for changing the attitude and translational velocity of a spin-stabilized body * * *." Applicant argued that the following language of claim 15 was patentably distinct over the art of record:

> [Clontrol means coupled to said valve for actuating said valve in a series of pulses occurring once per each revolution of said body about said axis and whose starting and stopping times are determined by the instantaneous angle of rotation of said body about said axis with respect to a reference point in space to produce a series of incremental forces

that result in a net force on said body in a predetermined direction.

Applicant also maintained that the following limitation of claims 16 made it patentable over the cited prior art:

> [M]eans associated with said body for expelling fluid more than once from a particular location thereon to exert a series of incremental forces on said body during several revolutions of said body about said axis, said means controlling the duration of each expulsion of fluid to be short compared to the time of one revolution of said body about said axis, said means controlling the time of occurrence of each expulsion of fluid to be at a predetermined part of the cycle of revolution of said body about said axis, * * *.

61. Similar arguments for patentability were made by plaintiff in connection with claims 17-19.

62. In the final office action of December 24, 1963, the examiner rejected claims 15-19 based upon prior art and also rejected them based upon an inadequate disclosure. In a rejection, which in substance is based on 35 U.S.C. § 112, the examiner stated:

> Claims 15-19, newly presented, are rejected as drawn to an inadequate disclosure. There is nothing in the original disclosure to indicate how the starting and stopping time or duration of the pulses is determined by the instantaneous angle of revolution of the body with respect to a reference point. The signals from 71 and 73 are sent by 90 and 50 to earth or another planet but there is no disclosure as to how such information is converted and used to send back to 90 for control of 93.

63. In response to this final rejection, Hughes filed an amendment in which it purported to respond to the rejection by requesting amendment of the specification and claims 15-19 "to more specifically recite that the control means actuates the thrust producing means or fluid jets during the same predetermined portion of each of a predetermined number of revolutions of the spin stabilized body or communications satellite."

64. The examiner denied entry of applicant's Rule 116 amendment because he found that the matter to be inserted into the specification was new matter: "[T]here being no support in the original disclosure" for this matter; the amendments to amendments to claims 15-19 would involve new matter; "[t]he proposed amendment has not remedied the inadequacy of disclosure * * *"; and "[t]he claims as amended would still fail to avoid the art rejections, neglecting the new matter inserted the amendment."

65. Thereafter, on June 23, 1964, Hughes filed a notice of appeal, but did not perfect it by timely filing its brief, and subsequently filed the Williams CIP application on August 21, 1964, from which the patent in suit ultimately issued. The parent application ultimately went abandoned.

66. Plaintiff's CIP application retained the disclosure of the 1960 parent application described above and added some additional material. This material consisted of Fig. 12 and the specification relating thereto. Figure 12 shows a ground-based analog controller for synchronizing the control signals it generates with the spin of the satellite. (*See* finding 53.) The court in *Hughes Aircraft Co.* v. *United*

States, 226 Ct.Cl. 640 F.2d 1193, 208 USPQ 785 (1980), found that this additional material:

> [Dlid not constitute "new material" but was an amplification that alleviated the deficiency in the information about the ground control device contained in the parent application.

67. The ground-based analog controller (*see* finding 53) had previously been described in a paper delivered by a Hughes employee to the 18th Annual Meeting of the Institute of Navigation, in San Diego, California, on June 18-20, 1962. This paper, entitled *Guidance and Control of 24-Hour Satellites*, by Mr. Roger W. Cole, an orbital analyst employed by plaintiff, later appeared in *Navigation*.

68. Thus, the Cole reference predated the CIP application, but not the parent application.

69. When originally filed, plaintiff's CIP application presented claims 1-18 for the examiner's consideration. Claims 4-7, 10 and 13 each recited "control" means" using language very similar to the language discussed previously in connection with claims 15-19 of the 1960 application. In the first office action following plaintiff's filing of the CIP, the examiner held that claims 4-7, 10 and 13 were not supported by the disclosure of the parent (1960) application. The examiner then rejected these claims under 35 U.S.C. § 102(b) because the invention was identically disclosed in a paper published more than one year prior to the filing date of the CIP application by one of plaintiff's own employees, Roger W. Cole. The examiner specifically stated that:

> The subject matter of applicant's Fig. 12, relating to the means for controlling the starting and

> stopping times, and duration, of control valve actuation, so as to be in synchronism with body rotation, as determined by a function of the instantaneous angle of rotation of the body with respect to a reference in space, is entitled to the filing date of the instant application only. Thus, Cole's disclosure operates as a statutory bar against such matter, as claimed, under 35 U.S.C. 102(b).

The examiner here was objecting to the details of control recited in claims 4-7, 10 and 13 which he felt were not disclosed in the parent application. The examiner was not making a finding that the disclosure of the original application would not enable one skilled in the art to use the satellite. Had he made such a finding, he would have rejected all the claims under 35 U.S.C. § 112, first paragraph, not just those reciting the objectionable details.

70. In response, plaintiff, by its July 21, 1965, amendment, cancelled claims 4, 6 and 7, and amended the "control means" portion of each of claims 5, 10 and 13 such that the recitation closely tracked that of originally filed claims 2 (of the 1960 parent application) discussed previously. (*See* finding 59.) With regard to the rejections based on Mr. Cole's article, plaintiff stated:

> Claims 5, 10 and 13 were rejected as being fully met by the Navigationarticle by Cole under 35 U.S.C. 102. Claims 5, 10 and 13 have been amended to delete reference to the control of starting and stopping times and the duration of valve actuation. Accordingly, Cole's disclosure can not now be considered to operate as a statutory bar against claims 5, 10 and 13.

71. In the next office action the examiner, apparently in agreement with plaintiff, dropped the rejection based on the Cole reference. However, all of the pending claims were finally rejected as being unpatentable over the newly cited patent to McLean (U.S. Patent No. 3,216,674) in view of a previously cited patent to Geyling (U.S. Patent No. 2,991,027) under 35 U.S.C. § 103. In response, Hughes cancelled the rejected claims and inserted, by amendment, new claims 19-21 into the application. These claims were allowed by the examiner without comment and became claims 1-3 of the patent in suit. It must be assumed then that the examiner felt that these claims too were entitled to the April 18, 1960, filing date of the original application.

72. The CIP application issued as the Williams patent (the patent in suit) consisting of the three claims (1-3) allowed, as described above:

Claim 1 in indented paragraph form provides:

1. Apparatus comprising:

   a. a body adapted to spin about an axis;

   b. fluid supply means associated with said body;

   c. a valve connected to said fluid supply means;

   d. fluid expulsion means disposed on said body and coupled with said valve and oriented to expel said fluid substantially along a line parallel to said axis and separated therefrom;

   e. means disposed on said body for providing an indication to a location external to

said body of the instantaneous spin angle position of said body about said axis and the orientation of said axis with reference to a fixed external coordinate system;

f. and means disposed on said body for receiving from said location control signals synchronized with said indication;

g. said valve being coupled to said last-named means and responsive to said control signals for applying fluid to said fluid expulsion means in synchronism therewith for precessing said body to orient said axis in a predetermined desired relationship with said fixed external coordinate system.

73. Claim 2 in indented paragraph form provides:

2. Apparatus for applying force to a spinning body by control from a location external to saidbodycomprising:

a. A body adapted to spin about a spin axis passing through the center of gravity thereof;

b. means for supplying fluid under pressure disposed within said body;

c. a controllable valve connected to said means for supplying a fluid;

d. jet-forming means disposed on said body and directed along a line substantially parallel to said spin axis and spaced apart therefrom;

e. said valve being connected to said jet--forming means for supplying fluid thereto when actuated;

f. wide angle means disposed on said body for providing an indication to a location external to said body of the instantaneous spin angle position of said body about said spin axis and the orientation of said spin axis with reference to a fixed external coordinate system;

g. and means disposed on said body for receiving from said location control signals synchronized with said indication;

h. said valve being coupled to said last--named means and responsive to said control signals for the actuation of said valve for precessing said body to orient said spin axis into a predetermined desired relationship with said fixed external coordinate system.

74. Claims 3 in indented paragraph form provides:

3. Apparatus for applying torque to a body spinning about a spin axis by control from a location external to said body, said torque being applied about a predetermined axis normal to said spin axis to precess said spin axis to point in a desired direction comprising:

a. a body adapted to spin about a spin axis passing through the center of gravity thereof;

b. fluid supply means for supplying a fluid under pressuredisposes within said body;

c. a controllable valve connected to said fluid supply means;

d. fluid expulsion means coupled to said valve and attached to said body and oriented to expel said fluid from said body substantially along a line parallel to said spin axis and spaced apart therefrom to enable torque to be applied about any axis normal to said spin axis passing through the center of gravity of said body;

e. wide angle optical means disposed on said body for providing an indication to a location external to said body of the instantaneous spin angle position of said body about said spin axis and the orientation of said spin axis with reference to a fixed external coordinate system;

f. and means disposed on said body for receiving from said location control signals synchronized with said indication;

g. said valve being coupled to said last--named means and responsive to said control signals for the repetitive actuation of said valve for precessing said body to orient said spin axis into a predetermined desired relationship with said fixed ex-Lernal coordinatesystem.

Scope of Remand

75. In an earlier recommended decision and conclusion of law (*Hughes Aircraft Co.* v. *United States*, 205 USPQ 381 (1979)), I found that the Williams patent (U.S. Patent No. 3,758,051) was invalid under 35 U.S.C. § 102(b). This conclusion was reached in

three steps. First, I found that the ground control device shown in Fig. 12 of the patent was a claimed element of all three claims. Next, I found that these claims were only entitled to the filing date of the continuation-in-part application (which matured into the patent in suit). This was because the parent application failed to provide sufficient support in accordance with 35 U.S.C. §§ 120 and 112, first paragraph, for the claims as I interpreted them. Finally, I found that the claims were invalid under 35 U.S.C. § 102(b) because the invention was described in a printed publication more than one year before the filing date of the CIP application.

76. In *Hughes Aircraft Co.* v. *United States*, 226 Ct.Cl. ____, 640 F.2d 1193, 208 USPQ 785 (1980), this court disagreed with my holding and found that:

> The claims of the patent cover solely the orbiting satellite and no other object, device, means or apparatus.

640 F.2d at 1195, 208 USPQ at 788. Thus, the ground controller is not an element of any of the claims. As discussed in finding 69, the examiner rejected some of the claims filed in the CIP application over the intervening Cole reference because the examiner felt that these claims were not supported by the disclosure in the parent case. In explaining how the examiner viewed the case, the court said:

> The problem with the original application * * * was * * * the failure * * * to give sufficient information regarding the ground control device to enable one skilled in the art to practice the invention.

640 F.2d at 1198, 208 USPQ at 790. The following concluding remarks make it clear, however, that the court thought the invention, as finally claimed, was properly supported by the original parent disclosure.

> The Williams patent is not invalid under 35 U.S.C. § 102(b). The case is remanded to Trial Judge Colaianni to file a recommended decision and findings on the other issues presented.

640 F.2d at 1199, 208 USPQ at 791.

35 U.S.C. § 103
The Prior Art

77. Of the numerous prior art references entered into evidence, only a few are pertinent. These references are:

Guthrie, *et al.*, U.S. Patent No. 3,010,677, Missile Control System, filed November 12, 1957, and issued November 28, 1961.

McLean, U.S. Patent No. 3,216,674, Proportional NavigationSystem for a Spinning Body in Free Space, filed June 8, 1959, and issued November 9, 1965.

Null, *et al.*, U.S. Patent No. 2,955,777, Infra-red Television Detector and Controller, filed August 19, 1946, and issued October 11, 1960.

Rosen, *et al.*, U.S. Patent No. 3,396,920, Apparatus for Changing the Orientation and Velocity of a Spinning Body Traversing a Path, filed December 30, 1959, and issued August 13, 1968.

Schlesman, U.S. Patent No. 2,852,208, Method and Apparatus for Telemetering Information from a Missile in Flight, filed April 11, 1950, and issued September 16, 1958.

Geyling, U.S. Patent No. 2,991,027, Passive Repeater for Satellite Communications Systems, filed December 15, 1959, and issued July 4, 1961.

78. The McLean patent ('674) issued more than five years after the Williams parent application was filed. Upon seeing the McLean patent, plaintiff immediately realized that it was very close prior art. In plaintiff's next response, plaintiff severely limited the scope of its claim coverage to avoid McLean. As discussed before (*see* finding 71), these more limited claims were allowed by the examiner. Soon thereafter, plaintiff decided it would be in its best interests to acquire rights in the patent. Hughes then negotiated an exclusive license with Dr. McLean. The claims of the McLean patent ('674) were limited to the target-seeking function of the disclosed McLean vehicle. As a result Hughes, through Dr. McLean, filed a reissue application on May 15, 1967, to broaden the claims of McLean to cover the broad pulsed jet precession means for attitude control of a spinning spacecraft disclosed by McLean. This reissue application was allowed, and on May 19, 1970, became reissue patent Re. 26,887.

79. Defendant claims that this reissue ('887) is prior art to the Williams patent, and then uses the reissue ('887) in its obviousness (35 U.S.C. § 103) defense. In addition, defendant notes that plaintiff never cited the reissue ('887) to the examiner, the Board of Patent Interferences, or Court of Customs and Patent Appeals (CCPA), and argues that this amounts to unclean hands. The McLean reissue ('887), however, adds nothing of significance to the disclosure of the original McLean patent ('674). The fact that the claims were broadened in the reissue

only confirms what was obvious to the examiner at the time he rejected the Williams application over the original McLean patent ('674). That being that the original McLean disclosure supported broad claims to the attitude control system. Such claims cover, but, of course, do not disclose attitude control systems like that of Williams. The only other changes made were to broaden the introductory language in the specification. A couple of examples will serve to illustrate the extent of these changes. In the following examples, the underlined material was added and the bracketed material deleted.

> The present invention relates to space vehicles and more particularly to an *orientation and velocity control* [automatic and self-contained navigation] system for a space vehicle spinning about its central axis as it travels in space. * * *
>
> By including, in the space vehicle assembly, a [tracking] system for detecting electromagnetic radiation [with its optical] [axis coinciding with the spin axis of the vehicle] and a variable thrust jet motor on the outer periphery of the spinning vehicle, the vehicle can be made to precess so as to [always] point its spin axis *in a predetermined direction* [at a target body that is emitting electromagnetic] [radiation].

These changes merely make explicit what was already known to the examiner when he cited McLean ('674) against Williams. That being that the pulsed precession jet subcombination disclosed for precessing the target seeker of McLean might be used to change the orientation of other spinning spacecraft. There is, however, no discussion of what other types

of spacecraft might use the pulsed precession jet. The only disclosed use is in the target-seeking vehicle originally disclosed in the McLean patent ('674).

Any reference to McLean in these findings is a reference to the McLean patent No. 3,216,674, unless otherwise indicated.

80. Of the references discussed above, only McLean ('674), Schlesman, and Geyling were cited by the examiner during the prosecution of the applications leading to the Williams patent. The McLean reissue (Re. 26,887), Guthrie, *et al.*, Null, *et al.*, and Rosen, *et al.*, were not cited by the examiner during the prosecution of the applications leading to the Williams patent.

81. Dr. McLean's work embodied in the McLean patent ('674) is the most pertinent prior art and is the cornerstone of defendant's 35 U.S.C. § 103 defense. The space vehicle disclosed in the McLean patent is closely related to the so-called "smart" missile technology developed during the 1950's, and, in particular, to the Navy's Sidewinder missile with which Dr. McLean was intimately involved. In fact, Dr. McLean was a member of the project staff for the Sidewinder missile.

82. The U.S. patent to Guthrie, *et al.*, No. 3,010,677, filed November 12, 1967, issued November 28, 1961, is a good example of the Sidewinder-type seeker system. The Sidewinder missile is intended to automatically track, follow, and destroy moving targets (especially planes) within the earth's atmosphere. It is contemplated that the target will attempt evasive maneuvers, but that the missile will constantly monitor these

movements and make the necessary changes in course to ensure collision.

The tracking device makes use of a Cassegrainian telescope to sight on the target. A Cassegrainian telescope is a form of reflecting telescope in which the rays are reflected from a primary mirror to a smaller secondary mirror, and then through an opening in the primary mirror to the eye of the observer. The telescope is mounted on a gyroscope such that its optical axis is aligned with the axis of rotation of the gyroscope. This combination is placed in the head of the missile. An infrared detector is positioned in the focal plane of the telescope. Once the missile gets an infrared ray emitting target (for example, the engines of a jet plane) within the sight of the telescope, the tracker follows it, attempting to keep the target in the center of the telescope's field of view. This information is interpreted within the missile and relayed to the control fins so that the missile is kept on a collision course in accordance with the principles of proportional navigation.

83. A brief discussion of the principles of proportional navigation follows:

The object of proportional navigation is to set a collision course for a missile with a moving target. First, it is important to realize that a finite amount of time will elapse between the time the missile is launched and the time of collision with the target. During this time, the target will have changed positions. In order to account for this, the launcher must anticipate where the target will be when the missile finally gets in the area of the target. It turns out that a missile is on a collision course with a target when the range between the missile and the

target is closing and the angle between the path of movement of the missile (the course line) and the line connecting the moving target and the missile (the sight line) remains constant. An example of this concept is shown in Fig. 16 of McLean which is reproduced below.

[image omitted]

Fig. 16 of McLean

Element 10 in the figure is the missile. The figure shows the relative position of the target and missile at four equally spaced instants of time.

Guiding a missile under the principles of proportional navigation then involves (1) maintaining a closing range between missile and target and (2) maintaining the angle between the course line and sight line constant. Although this is not a complete explanation, for the purposes of this case all that need be kept in mind is that when a change in the angle between the course line and sight line is detected the missile direction must be changed in an amount proportional to the rate of change of the angle in order to maintain a collision course with the target.

84. Figure 2 of Guthrie, *et al.*, reprinted below, shows the transparent front end 24 of the missile and the rotating gyroscope 16. The Cassegrainian telescope (*see* mirrors 16 and 17) is mounted as a part of the gyro

[image omitted]

Fig. 2 of Guthrie

and is used to monitor the position of the infrared ray emitting target so that the angle between the path movement of the missile (the course line) and the line

connecting the moving target and the missile (the sight line) can be determined. The axis of the telescope points along the sight line at the target and, as a result, the spin axis of the gyro (which is coincident with the optical axis of the telescope) is seldom positioned in line with the course line of the missile. When a change in the target position is detected, the gyro 16 is precessed magnetically (using coils 27) so that the spin axis of the gyro is maintained in alignment with the target. This information is then relayed to the adjustable control surfaces which act to change the course of the missile as needed. In the particular missile described in Guthrie, the control surfaces are retractable wings.

85. Applying the principles he was aware of tron the Sidewinder project, Dr. McLean came up with a target-seeking vehicle useful for applications in outer space. Realizing that aerodynamic forces are not a factor in the vacuum of space, he decided that the entire vehicle could be set spinning and used as the gyroscope needed to determine the angle between the course line of the vehicle and the sight line from the vehicle to the target. The vehicle described in the McLean patent was, however, never actually built.

86. McLean's vehicle is shown in Fig. 1 of the patent, which is reproduced below.

[image omitted]

Fig. 3 of McLean

As can be seen, the Cassegrainian telescope (see mirrors 18 and 19) is mounted on a spinning frame with the detector 12 positioned at the observation point of the telescope. The detector provides the information about the position of the target with

respect to the spin axis of the vehicle (which is coincident with the telescope axis) that is used to precess the sidewinder missile, this information is used to precess the gyro into alignment with the target and to change the course of the missile. In the vehicle of McLean, the information is used to precess the entire space vehicle into alignment with the target and to change the course of the vehicle. However, the means used to provide these functions in the Sidewinder missile (electromagnets and adjustable control surfaces) would simply not work for McLean's space vehicle.

87. Dr. McLean knew from basic gyroscope dynamics that in order to precess his spinning space vehicle he needed to provide a torque about an axis perpendicular to the spin axis of the vehicle. I order to provide this torque, Dr. McLean positioned a precessing jet near the edge of the vehicle, spaced from the spin axis and aligned such that the thrust force of the jet is along a line parallel to the spin axis. The portion of the spin cycle during which the jet is pulsed determines the direction of precession.

The precessing jet changes only the orientation of the spin axis of the vehicle. In order to change the course, McLean provides a lateral jet 32 pointing outwardly from the edge of the vehicle such that the thrust force of the jet is directed through the center of mass of the vehicle. The portion of the spin cycle during which the lateral jet is pulsed determines the course correction. McLean assumes that a forward velocity is imparted to the vehicle when it is launched into outer space so that no additional forward thrust is needed. (*See* col. 6, lines 65-68, of McLean.)

88.

[image omitted]

Fig. 3 of McLean

Figure 3 of McLean is reprinted here as an aid in explaining how the detector system works. Reticle 20 is placed in the focal plane of the telescope with an infrared detector 22 positioned directly behind it. The reticle is a thin circular element divided into two halves with a line through the middle. One-half is transparent and the other is opaque. When the telescope gets the infrared ray emitting target within its field of view, the image appears at the reticle. If the target is aligned with the telescope axis, then, as the vehicle and the reticle spin, the photodetector 22 detects only a constant amount of infrared radiation because the image of the target is in the center of reticle.

If the target, due for example to relative acceleration, should move away from alignment with the axis of the telescope, the image of the target will be blocked from the detector 22 during half of the spin cycle and permitted to pass during the other half. This results in an alternating signal being provided by the detector 22.

89. It is important to ascertain exactly how much information this alternating signal provides. In this connection, it is useful to consider the line dividing the reticle 20 into opaque and clear halves together with the spin axis (or telescope axis) as forming an imaginary plane spinning at the same rate as the space vehicle. When the current from the detector 22 goes from low to high, the imaginary plane has swept past the target and the image of the target has gone

from the opaque portion of the reticle to the clear part. This provides enough information to determine when during the spin cycle the precessing jet needs to be fired in order to precess the spin axis towards alignment with the target. The detector 22 is connected through an amplifier to the precession jet so that every time the signal goes from low to high the jet is activated. By positioning the jet properly with respect to the reticle, the jet is activated during the correct portion of the spin cycle to provide the desired precession (toward the target). Additionally, in order to make adjustments without the need to physically change the position of the reticle, a phase shifting circuit is provided. The signal that activates the precession jet simultaneously activates the lateral jet in order to maintain the spinning vehicle on a collision course.

90. In a preferred embodiment of the reticle, McLean provides alternately opaque and clear segments in the clear half of the reticle. Because the segments are shaped like pie slices, a target that is close to alignment and provides an image close to the center of the reticle will be partially obscured by the edges of the segments at all times. When the image of the target is further from the center, more of it will be exposed to the detector. The resulting differences in current are proportional to the angle between the spin axis and the line of sight to the target. These differences in current are applied through an amplifier to vary the thrust from the jets—a higher thrust being applied where the angle is greater.

Because the vehicle of McLean is a target seeker, it would be desirable to eliminate as many extraneous signals as possible. Although the disclosure appears

not to address this issue, it is clear that the field of view of the telescope must be fairly narrow. One of defendant's witnesses at trial suggested that the field of view is of the order of 8 to 10 degrees.

91. Although the McLean space vehicle was developed in the context of seek-and-(destroy-type missiles, there appears to be no discussion of any particular use apart from general navigation towards a target. The disclosure at col. 2, lines 63-64, of McLean suggests that the target could be the moon, a planet, or some other space vehicle. No other potential targets are discussed in the specification.

92. The U.S. patent to Null, *et al.*, patent No. 2,955,777, filed August 19, 1946, and issued October 11, 1960, shows an automatic target-seeking missile for use within the earth's atmosphere. Radiation emitted from the target is detected in the front end of the missile and used to make course corrections automatically where necessary. The interesting fact for the purpose of this case is that Null, *et al.*, suggests that in order to prevent the missile from accidentally acquiring the heat emitting engines of the mother plane as a target, a remote control system should be provided at the launching station (the mother plane in Null, *et al.*) which is capable of overriding the automatic controls.

93. The patent to Rosen, *et al.*, No. 3,396,920, was filed December 30, 1959, and issued August 13, 1968. This patent is sometimes referred to as the Rosen-Williams patent because Donald D. Williams (the inventor in the Williams patent in suit) was a co-inventor. The Rosen-Williams patent was discussed previously (see findings 19-20) and discloses a spin-stabilized satellite for use especially in an orbit

synchronized with the spin of the earth. Rosen, *et al.*, uses a directional antenna aligned with the spin axis and solves the orientation problem by stopping the spin, changing the position of the satellite, and then starting the spin up again. All of this is done by remote control from the ground.

94. The Schlesman patent, No. 2,852,208, issued September 16, 1958, discloses a rotating missile in which gyro-stabilized reference means is provided to telemeter instantaneous signals, indicative of the missile's declination angle and rotational position, from the missile to a synchronously rotating visual display at a flight director's station, so that the director can control the firing time of steering charges on the missile when it has reached the rotational position effective to produce the desired change in the course of the missile.

95. The Geyling patent, No. 2,991,027, issued July 4, 1961, discloses a passive repeater radio communications satellite spun up to inflate or erect its spherical radio-wave reflecting metallized envelope. The disclosed satellite carries remotely controlled gas jets for spinning, aligning and correcting the orbit of the satellite while it is in a geo-stationary orbit. There is no indication in the disclosure that the orientation of the spin axis as opposed to the position of the satellite in space is important.

The Differences Between the Claims of Williams and the Prior Art

96. Defendant's basic argument is that the McLean device includes all the elements of the claims of Williams except for the remote control aspect and

that provisions for remote control would have been an obvious addition to the device of McLean.

The section of claim 1 that gives defendant the most trouble in this regard is section (e). There is no need to discuss the other two claims of the Williams patent separately because they contain substantially the same subject matter with differences that are not material to the issues involved here. Section (e) of claim 1 of Williams reads:

> e. means disposed on said body for providing an indication to a location external to said body of the instantaneous spin angle position of said body about said axis and the orientation of said axis with reference to a fixed external coordinate system; * * *.

At trial, when the defendant's expert witness, Mr. Wilhelm was asked to compare the language of this section with the device of McLean, he said: "Well, that one starts to give me a little trouble." Mr. Wilhelm went on to indicate that the McLean telescope sensor does not fit the classical definition of indicating the spacecraft's instantaneous spin angle position and spin axis orientation with reference to a fixed coordinate system. Mr. Wilhelm hastened to add that while McLean did not provide the claimed indications, neither did Williams.

97. This court, in the decision of December 17, 1980 (*Hughes Aircraft Co.* v. *United States*, 226 Ct.Cl. ____, 640 F.2d 1193, 208 USPQ 785 (1980)), adopted most of the findings of fact made at the trial level. *Id.* at 640 F.2d at 1193, 208 USPQ at 786. These findings are now established facts of the case. Findings 33-61 show that the disclosure supports the recitations of

the claims, and particularly the means for providing the indication to the earth station required by section (e) of claim 1.

98. In determining the differences between claim 1 of Williams and the device of McLean, the best place to start is to look at what it is that section (e) of claim 1 requires. This section calls for means providing an indication o the instantaneous spin angle position (ISA) of the spinning body with reference to a fixed external coordinate system. A fixed external coordinate system is one fixed with respect to the distant stars. The instantaneous spin angle position (ISA) with respect to a fixed external coordinate system is more difficult to define. (*See* finding 34 for definition of the ISA.) In order to precess the body in a predetermined direction, it is necessary that the angle between the line connecting the precessing jet with the center of mass of, the body and the plane formed by the line connecting a known reference point in an external coordinate system (*e.g.*, the sun or a star) with the center of the body and the spin axis be known for any given instant of time. This angle, when given for a particular instant of time, is the instantaneous spin angle position with reference to a fixed external coordinate system. The minimum amount of information needed to determine the ISA with respect to a fixed external coordinate system is (1) the spin rate of the body, and (2) the instant in time at which the plane formed by the spin axis of the body and the line connecting the precessing jet with the center of mass of the body sweeps past a known fixed point (*e.g.*, the sun or a star) in a fixed external coordinate system. The direction of spin must also be known, but for all spacecraft considered here the direction of spin is

assumed to be known because the spin is intentionally induced.

Additionally, section (e) requires means for indicating the orientation of the spin axis of the body with reference to a fixed external coordinate system. The meaning of this requirement is apparent on its face.

99. Section (e) of claim 1 requires that there be an indication provided of both the ISA and the spin axis orientation. Sections (f) and (g) go on to explain that this information is to be used to generate synchronized signals to control thepulsing of the axial jet:

> [F]or precessing said body to orient said [spin] axis in a predetermined desired relationship with said fixed external coordinate system.

In order to perform the claimed function, it is necessary that both the indication of the ISA and the indication of the spin axis orientation must be provided at the same time. This is because in order to precess the body into a desired orientation within a fixed external coordinate system, the initial orientation must be known, and in order to pulse the jet in the proper portion of spin cycle to provide the torque needed for the desired precession, the angular position of the axial jet must be known. This does not mean that the information from which the ISA and orientation is determined must be transmitted at the same time, it only means that both the ISA and the orientation must be capable of being determined on the ground at the same time. Thus, claim 1 requires that the indication of the ISA and the indication of the spin axis orientation be provided at the same time, because otherwise the device would not be capable of performing the claimed function.

100. The time lapse between the determination that a course change is necessary and the implementation of the course change is critical in the context of target seeking, particularly where the target is moving. Because of this, the space vehicle of McLean is wired to provide both course correction and orientation correction at the same time that the sensor discovers that such corrections are needed. In Williams, the time lapse is not as critical. Once the satellite of Williams is placed in synchronous orbit around the earth, the orientation needs to be changed so as to align the spin axis of the satellite with the earth as soon as possible. This orientation provides optimal antenna reception. There is no need, however, to change the orientation immediately. As a result, the satellite is wired so that no orientation correction is made until the ground controller decides that it is time to make a correction.

101. One of the steps in defendant's argument that McLean provides the indications required by claim 1 includes a finding that the McLean spacecraft's location can be determined through range tracking It appears to be likely that at least for some ranges, the position of the McLean space vehicle could be determined.

The portion of the trial record upon which defendant relies for support is the redirect examination of defendant's witness, Dr. Howard A. Wilcox, and reads as follows:

> Defendant's counsel: [I]f the satellite or the spacecraft were such that the axis were pointing directly toward the target, at that point in time, what would be the nature of the signal coming

down? If it were pointing directly toward the distant target for example, a star.

Dr. Wilcox: At that point there would be no signal coming down.

Defendant's counsel: I see, now, you indicated that the distant target is presumed to be known, for example Venus or some distant star. And presupposing also that the position of the spacecraft is known because of range tracking and what have you, and that situation with the spin axis pointing directly toward the target as evidenced by the absence of a signal coming down, and knowing the position of the spacecraft, at that point in time then, one could determine the direction that the spin axis were pointing in inertial space, is this correct?

Dr. Wilcox: Yes, you'd have a complete fix on the spacecraft at thatpoint.

102. Defendant argues that the target of McLean could be a celestial body fixed in inertial space. The only such celestial bodies that the court can think of are stars and the sun. However, McLean speaks only of "the moon, a planet, or some other space vehicle" as potential targets. (*See* finding 91.) Because the angle between the line of sight to the target and the spin axis is determined by a lesser or greater registered intensity depending on where along the pie-slice shaped reticle segment the target image falls (*see* finding 90) the vehicle would presumably need to be calibrated differently for different targets. This raises at least some question about whether the angle between the spin axis and the target could be deter-

mined accurately where the target is of a different intensity than the vehicle was designed for. McLean, however, does specifically mention planets as possible targets. Due to the fact that the positions of the planets and the earth in a fixed coordinate system are known, any information that could be determined was the target—a star, or the sun, could probably be determined, albeit somewhat more laboriously, where the target is a planet. For convenience, it will be assumed that the target is a star.

103. The space vehicle of McLean can be treated as having two modes. The quiet mode is when the spin axis of the vehicle is directly aligned with the target. Only a steady signal is produced by the sensor. The alternating mode occurs when the spin axis is out of alignment with the target. During this mode, an alternating signal is produced as the target image falls on the dark and then the clear parts of the reticle.

104. When the sensor emits a steady state signal, the orientation of the spin axis in a fixed external coordinate system can be determined. This is because the position of the satellite with respect to the earth is known through range-tracking techniques and the signal indicates that the spin axis is pointing directly at a known star. However, there is no indication of the instantaneous spin angle position because the sensor is providing only a steady state signal.

105. When the sensor signal is alternating, the instantaneous spin angle position with reference to a fixed external coordinate system can be determined. In order to determine the ISA, the spin rate is needed (*see* finding 98) and, in order to determine the spin rate, at least two successive pulses are needed (compare finding 39). It is assumed that it would take at

least two successive pulses from the precession jet before the spin axis is aligned with the target. In the case of McLean, it is best to imagine a rotating plane defined by the spin axis and the line between the opaque and clear portions of the reticle. (*See* finding 89.) The position of the axial jet with respect to this plane is known. Thus, after the second time this plane sweeps past the star as indicated by the signals generated by the sensor, the angular velocity (*i.e.*, the spin rate) of the vehicle can be determined. This result is not affected by the fact that between signals the orientation of the vehicle has changed. This is because the precession is in a direction towards the target star. The time at which the plane sweeps past the target star (which is fixed in an external coordinate system) is determined by observing when the sensor changes from a low signal to a high signal. In accordance with the definition discussed earlier, this is enough information to determine the instantaneous spin angle position.

The orientation of the spin axis, however, cannot be determined without ambiguity while the McLean device is in the alternating signal mode. The position of the target star in a fixed external coordinate system is known. The angle (let us call it the "star angle") between the line connecting the star to the center of the vehicle and the spin axis of the vehicle is known because of the relative intensity of the sensor signal. The position of the vehicle is known through the use of range-tracking techniques. However, this information still does not define the orientation of the spin axis of the vehicle with respect to a fixed external coordinate system. The spin axis may lie anywhere within a "cone of ambiguity." (*See* finding 41.)

106. For the purposes of McLean, there is no need to resolve this ambiguity. All McLean needs to know to precess towards the target is the relative position of the spin axis and the axial precession jet with respect to the target. In Williams, however, the ambiguity must be resolved in order to permit changes in orientation to a predetermined orientation *within a fixed external coordinate system.* (*See* finding 41.) It is the means for providing this additional information in combination with the remote control which was stressed as the major distinguishing feature in arguments made by the plaintiff before the examiner during the prosecution of the Williams application.

107. Defendant, however, points out that the disclosed embodiment of Williams, like McLean, only provides an indication of the angle between the line from the sun to the center of the satellite and the spin axis. Thus, just as in McLean, more information is needed in Williams to resolve the ambiguity. Unlike the situation with McLean, however, findings of fact 3361 made at the trial level and adopted by the court in an earlier proceeding (*Hughes Aircraft Co.* v. *United States*, 226 Ct.Cl. - _____, 640 F.2d 1193, 208 USPQ 785 (1980)), show that the disclosure in the Williams patent is sufficient to support the language of the claims. (*See* findings 41 and 97.) This language requires an unambiguous indication of the orientation of the spin axis in a fixed external coordinate system. In discussing the cone of ambiguity problem of the Williams satellite, the court found:

> 45. The existence of these ambiguities and the techniques for overcoming them would have been obvious to any person of ordinary skill in the art of celestial navigation.

46. Such a person would know that these ambiguities could be resolved in at least two different ways: by dead reckoning; or by adding an earth sensor. The disclosed embodiment does teach the use of an antenna with an asymmetric radiation pattern as a crude earth sensor.

Hughes Aircraft Co., 226 Ct.Cl. at ____, 640 F.2d at 1215, 208 USPQ at 805.

These findings deal exclusively with the Williams satellite. There is no suggestion from the findings that they would be applicable to the target-seeking space vehicle of McLean. Furthermore, it appears likely that these findings would not apply to McLean due to the functional and related structural differences between the McLean and the Williams devices.

108. The findings made above show that during the alternating signal mode where the spin axis of McLean is out of alignment with the target star, McLean provides an indication of the instantaneous spin angle position, but not the orientation of the spin axis within a fixed external coordinate system. (*See* finding 105.) During the quiet mode when the spin axis is aligned with the target star, McLean provides an indication of the orientation of the spin axis, but not the instantaneous spin angle position within a fixed external coordinate system. (*See* finding 104.) As discussed in finding 99, the claims require that the ISA and orientation be indicated at the same time in order to permit controlled precession in a fixed external coordinate system.

109. In discussing various additions and modifications that could be made, the Williams specification makes the following comments:

> Further, a jet or jets may be produced on a spinning body to achieve simultaneous change in velocity and attitude so as to realize, for example, a proportional navigation course. By this means a target seeking vehicle may be constructed in accordance with the invention.

The claims in issue now, however, were narrowed by amendment in response to the examiner's citation of the McLean reference many years after the original application was filed.

Level of Ordinary Skill
in the Art

110. After a careful review of the record, I have determined that the level of ordinary skill in this art was that of an aerospace engineer practicing in 1960 with some exposure to the problems of synchronous orbit telecommunication satellites.

111. Defendant suggests that it would have been obvious to close the lateral course correction jet of McLean and to mount the McLean sensor on the side of the McLean space vehicle. There is, however, no suggestion in the art to make these changes. Furthermore, if these changes were made, the modified McLean space vehicle would no longer be able to perform its intended target-seeking function. Without the lateral jet, the target could not be pursued in accordance with the principles of proportional navigation, and it is not clear how the vehicle would work at all with the narrow field McLean sensor mounted on the side of the vehicle.

Inequitable Conduct

112. The Patent and Trademark Office examiner first cited the McLean patent (No. 3,216,674) in the examiner's' January 10, 1966, office action. Both the examiner and the plaintiff immediately recognized the relevance of McLean. They both saw that although McLean was not designed for earth orbit, it clearly disclosed the basic synchronously pulsed jet precession concept which plaintiff had broadly claimed. As a result, plaintiff in its April 29, 1966, response severely contracted the scope of its claim coverage to avoid the McLean reference.

The newly submitted claims were accompanied by about 11 pages of remarks which explained the plaintiff's interpretation of the cited references (including McLean) and the plaintiff's explanation of how it thought the new claims avoided these references. A few examples of the comments will suffice to capture the flavor of the remarks. Plaintiff argued in the response that:

> McLean's infrared telescope does not indicate the instantaneous spin angle position of his body *with reference to a fixed external coordinate system, and in does not indicate the orientation of reference to a fixed external coordinate system.* [Emphasis in original.]
>
> * * * * *
>
> No fixed external coordinate system in involved [in McLean].
>
> * * * * *

> McLean's device would be incapable of performing the function of applicant's claimed invention; namely re-orienting the spin axis to point in a desired direction while in orbit. It is only capable of pointing the spin axis at a target.
>
> * * * * *
>
> There is no thought [in McLean] of orienting the spin axis of a satellite in orbit.

113. On May 15, 1967, plaintiff, through Dr. McLean, filed a reissue application to broaden the claims of the original McLean patent (No. 3,216,674). This reissue was allowed, and on May 19, 1970, became reissue patent Re. 26,887. (*See* finding 78.)

In the reissue declaration, the plaintiff, through the inventor, Dr. William B. McLean, said:

> [Tlhat he claimed less than the could rightfully have claimed in the patent in that all the claims therein were inadvertently limited to specific applications of the invention to the field of self-contained proportional navigation apparatus for following a collision course to a target body, whereas the inventionis not so limited, but has utility generally where control of the velocity and attitude of a spinning body is desired as in artificial satellites of the earth.

In the remarks of the April 1966 response, plaintiff states:

> McLean * * * is [not] concerned with orienting the spin axis of a satellite in orbit by precession. * * * [McLean does not disclose] apparatus which could produce such a mode of operation or result.

114. In the reissue declaration, the question is whether or not through inadvertent error the original patent is partly inoperative to protect McLean's invention by reason of the fact that it claims less than he had a right to claim in the patent, 35 U.S.C. § 251. In order to show this, plaintiff points out what would be obvious to anyone who understands both McLean and Williams. That is that the pulsed precession jet concept used to precess the McLean vehicle could be used to precess and thus change the orientation of any spinning space body, but that the original claims of McLean were limited to the target-seeking application.

Infringement

115. The accused spacecraft systems have, for convenience, been divided into two groups. The first group consists of Skynet II, NATO II, DSCS II, IMP (H and J), and the programmed mode of Pioneer (10 and 11). These systems will be referred to as "store and execute" (S/E) systems. The second group consists of Solrad (9 and 10) and the real time mode of Pioneer (10 and 11). These two systems will be referred to as "real time" systems. The reasons for these names will become apparent as the systems are described.

The Store and Execute Systems

116. In considering whether or not the store-and-execute systems infringe the claims of the Williams patent (No. 3,758,051), only clauses (e), (f) and (g) of claim 1 need be considered. These clauses read as follows:

e. means disposed on said body for providing an indication to a location external to said body of

the instantaneous spin angle position of said body about said axis and the orientation of said axis with reference to a fixed external coordinate system;

f. and means disposed on said body for receiving from said location control signals synchronized with said indication;

g. said valve being coupled to said last-named means and responsive to said control signals for applying fluid to said fluid expulsion means in synchronism therewith for precessing said body to orient said axis in a predetermined desired relationship with said fixed external coordinate system.

Claims 2 and 3 claim substantially the same subject matter a little more narrowly.

117. The first step is to ascertain the meaning of the portion of claim 1, quoted in finding 116 above. The instantaneous spin angle position (ISA) with respect to a fixed coordinate system has been defined previously in findings 34, 39 and 98. In order to understand what the ISA is, it is important to see what purpose this information serves. Application of the torque needed to precess the spinning spacecraft is provided by a jet offset from the spin axis. This jet is spinning with the spacecraft. In order to provide a torque in only one desired direction, the jet must be pulsed on for only a short time while it passes through the proper position. In order to pulse the jet in the proper position, the angle between the plane formed by the spin axis and a line from the jet to the center of the mass of the satellite (which plane is constantly rotating) and the reference plane formed

by the spin axis and the sun vector (the line from the sun to the center of mass of the satellite) must be known for all instants of time. Thus, the instantaneous spin angle position in a fixed external coordinate system is a measure of where the precessing jet is in its cycle relative to a reference plane at any given instant of time. Because the spacecraft if always spinning, the ISA is a constantly changing value.

118. The claim requires only that an "indication" of the ISA be provided to an external location and not the ISA itself. The distinction between providing an "indication" of the ISA and providing the ISA itself is clear after gaining an understanding of the operation of the Williams system. In order to synchronize the precession jet commands sent from the earth controller with the spin of the Williams satellite, the ISA must be known on the ground. However, there is no need to send a constant series of angles (the ISA for any given instant) directly from the satellite. All that is needed is to send enough information from the satellite such that the instantaneous spin angle position can be determined for any given instant of time. Plaintiff recognized this and, as a result, decided to use the broader language indication of the instantaneous spin angle position."

119. The interpretation that "indication" of the ISA means enough information from which the ISA can be determined is consistent with the requirements of the rest of the claim. Clauses (e), (f) and (g) of claim 1 require that (1) an indication of the ISA be provided to an external location; (2) that the spinning body have means for receiving control signals that are synchronized with the indication of the ISA; and (3) that fluid be applied to the fluid

expulsion means (the precession jet) in response to the control signals so that the body is precessed in a predetermined direction. Although other elements are claimed in this portion of the claim, these are the only elements that need be considered here. It is clear that these elements come into play after the ground control has determined (1) the orientation of the spin axis of the body in a fixed external coordinate system; (2) the desired orientation of the spin axis; and (3) where during the spin angle the precession jet must be pulsed to precess the spin axis towards the desired orientation. Up to this point there is no need for the ground control to know what the ISA is. In the scheme of the claim, the ground control next will send a control signal synchronized with the particular point in the spin period during which the precession jet should be pulsed. The spinning body then has means for pulsing the precession jet in response to the control signal.

120. In order to permit the ground control to pulse the precession jet during the proper portion of the spin cycle, there must be a known fixed time period between the receipt of a control signal and the activation of the precession jet. In the exemplary embodiment disclosed in the Williams patent, the fixed time period is as close to zero as possible. The only delay is the time it takes the signal to travel through the electronics and the time it takes to activate the valve. (*See* findings 51, 52 and 57.)

121. Claim 1, then calls for a spinning body having (1) means for providing information sufficient to determine the ISA to an external location, and (2) means for pulsing the precession jet within a fixed time period after the receipt of a control signal from

the remote location. Thus, even though the ground control itself is not an element of the claim, the structure called for on the spinning body limits the claim to an attitude control system wherein a ground controller is needed to determine the ISA and use it to pulse the precession jet during the desired portion of the spin cycle.

Skynet II, NATO II, and DSCS II "Store-and-Execute" Systems

Skyner II System Details

122. Skynet II is a United Kingdom-owned spacecraft system used for relaying military communications between a number of strategically and tactically located earth stations situated between the Eastern Atlantic and Western Pacific.

123. The Skynet II system is intended to employ spacecraft placed in a nominally geostationary orbit over the Indian Ocean. When the spacecraft is positioned at the correct longitude, it is kept there (within 0.5 degrees) for its operational lifetime.

124. The Skynet II spacecraft itself is cylindrical. When in orbit, it is spin stabilized nominally at about 90 r.p.m.

125. The Skynet II spacecraft has five major subsystems comprising (i) the communications subsystem; (ii) the attitude and orbit control subsystem; (iii) the electrical power subsystem; (iv) the reaction control subsystem; and (v) the telemetry, tracking and command subsystem.

126. The Skyner II attitude and orbital control subsystem comprises the following pertinent functional equipment associated with satellite spin

axis attitude control: (i) the sun sensor assembly; (ii) the earth sensor assembly; (iii) the electronic unit; and (iv) the nutation damper assembly.

127. The Skynet II reaction control equipment subsystem comprises the following pertinent functional equipment associated with spacecraft spin axis attitude control: (i) spherical propellant tanks, connected through (ii) valves to (iii) axial precession jet thrusters.

128. The Skynet II telemetry, tracking and command subsystem comprises the following pertinent functional equipment associated with spacecraft spin axis attitude control: (i) an antenna; (ii) a command receiver; (iii) a command unit; and (iv) a telemetry unit.

129. The ground control facility for the Skynet II launch, orbit initialization, and placement-in the required stationkeeping position is the U.S. Air Force Satellite Control Facility (AFSCF). The AFSCF is comprised of two major functional entities, the Satellite Test Center at Sunnyvale, California, and various Remote Tracking Stations located around the world. Once the Skynet II spacecraft are placed on station, control is transferred to United Kingdom's Telemetry and Command Station (TCS), Oakhanger, Hampshire, England.

130. Commands to the Skynet II spacecraft are computer programmed at the AFSCF (or TCS) into a format which the spacecraft telemetry, tracking and command subsystem will accept and store. To ensure correct operation, commands which are stored on board the spacecraft are matched against the command words also stored at the AFSCF (or TCS) com-

puter by returning the spacecraft stored command words via telemetry to the AFSCF (or TCS) for verification. Subsequent to verification, an execute command must then be transmitted to the spacecraft in order for the spacecraft to execute the stored and verified commands.

131. The Skynet II communications link must be available continuously during the operational life of the spacecraft. To facilitate such requirements, the communications antenna (which is mechanically despun) must always point along a line from the spacecraft to the center of the earth.

132. The Skynet II antenna-pointing requirement involves the use of the attitude and orbit control subsystem and requires that the spin axis be maintained perpendicular to the orbit plane. Changing the spin axis attitude necessarily involves exercise of (i) the spacecraft attitude and orbit control subsystem; (ii) the spacecraft's telemetry tracking and command subsystem; (iii) the spacecraft's reaction control equipment subsystem; and (iv) the AFSCF or the United Kingdom's TCS depending upon where in its life cycle any given Skynet II spacecraft is.

133. The Skynet II attitude and orbital control sun sensor assembly comprising redundant (two) sun sensors (the output from only one sensor being used at any one time), when operating in conjunction with the electronic unit, generates a digital word for telemetry representing the value of the included angle between the spacecraft spin axis and a line from the sun to the spacecraft (the so-called "sun angle" or "solar aspect angle").

134. The Skynet II attitude and orbital control sun sensor assembly operating in conjunction with the electronic unit also generates a digital word for telemetry representing the spin rate (in revolutions per minute) of the spacecraft about its spin axis.

135. The Skynet II attitude and orbital control earth sensor assembly comprising redundant (two) pairs of earth sensors (which pair used is selected by ground command, with one earth sensor scanning a north earth chord and the other earth sensor of the selected pair scanning a south earth chord) when operating in conjunction with the electronic unit, generates two digital words for telemetry, one word representing the north earth chord width and one word representing the south earth chord width.

136. The instantaneous spin angle position of a spacecraft is an indication or representation of where the spacecraft is in its 360 degrees spin cycle (rotation) about its spin axis (axis of rotation) at any given instant of time.

137. A complete set of Skynet II spacecraft attitude data consists of (i) the so-called "sun angle" or "solar aspect angle"; (ii) the spacecraft spin rate; and (iii) the earth chord width (north and south). During a telemetry "pass," one complete set is sampled and telemetered in digital format to a given remote tracking station.

138. A set of Skynet II spacecraft attitude data does not contain data representing the instantaneous spin angle position of the spacecraft.

139. An indication of the instantaneous spin angle position of the spacecraft is not telemetered or otherwise provided to any remote tracking station and also

is not available to the Air Force Satellite Control Facility for any purpose.

140. The Skynet II spacecraft attitude data telemetered to the remote tracking station (spacecraft spin rate, north and south earth chord widths and sun angle (solar aspect angle)) are relayed to the Satellite Test Center (STC) at Sunnyvale, California, via computer-to-computer communication lines.

141. The Skynet II spacecraft data is then fed into the "3800" computer. The "3800" computer then computes the Skynet II spacecraft orbit position and the Skynet II spacecraft's spin axis attitude.

142. The computed Skynet II spacecraft attitude is then compared by the "3800" computer operator to what has been determined by the Skynet II project office to be the desired Skynet II spacecraft attitude. After comparison and consultation with the Skynet II project office, a decision is made as to whether or not an attitude correction maneuver is necessary.

143. If a Skynet II spacecraft attitude correction maneuver is necessary, the "3800" computer operator instructs the "3800" computer as to the desired spacecraft attitude and the approximate time the spacecraft attitude correction maneuver will be initiated. The "3800" computer then computes the command information necessary to perform the spacecraft attitude correction maneuver.

144. No spacecraft instantaneous spin angle position information is either utilized or needed by the "3800" computer in computing this command information necessary to perform the spacecraft attitude correction maneuver.

145. The command information is then transmitted via the computer-to-computer communications lines to the remote tracking station responsible for initiating the spacecraft attitude correction maneuver. The command information is then entered into the remote tracking station computer.

146. Transmission of the command signal sequence to the Skynet II spacecraft is initiated by telephonic orders from the mission control complex at the STC, Sunnyvale, California, to the remote tracking station responsible for commanding the spacecraft. The remote tracking station console operator is told verbally by the mission controller at the STC which command signals to send and the time of transmission. The remote tracking station console operator pushes appropriate buttons to select the command signals and initiate transmission. The remote tracking station computer then feeds the proper command signals to the transmitter which transmits them to the satellite.

147. In order for a Skynet II spacecraft attitude correction maneuver to take place, a series of commands in sequence must be transmitted. The first part of the series of commands, containing the firing parameters of the spacecraft axial precession jet thruster, are transmitted to and stored in registers on board the spacecraft. The command information thus stored in the spacecraft is then relayed back to the remote tracking station and compared to the desired command so that if they are identical, an execute command is next transmitted to the spacecraft.

148. The stored commands contain: (i) the number of precession jet thruster pulses to be fired; (ii) which

precession jet thruster to be fired; and (iii) the time delay between the sensing of a sun line crossing and the firing of the precession jet thruster. The stored axial precession jet thruster firing sequence is completely executed by the Skynet II spacecraft command and reaction control subsystems automatically and autonomously without the use of any further commands from the remote tracking station.

149. The Skyner II spacecraft command and reaction control subsystems execute the required spacecraft attitude maneuver using the combination of commands (which are not synchronized in any manner with any event in the spacecraft's environment) and an on-board signal generated by the crossing of the sun line by the spacecraft sun sensor. This operation affects the attitude maneuver without any further intervention by the remote tracking station.

150. The Skynet II axial precession thruster jets are not activated either immediately upon spacecraft receipt of the execute command or at the end of a fixed or invariable time interval following spacecraft receipt of the execute command; nor is there any configuration of the system possible which would enable the execute command signals transmitted by the remote tracking station to operate the precession jet thrusters immediately upon their receipt at the spacecraft, *i.e.*, in "real time."

NATO II System Details

151. The NATO II spacecraft provide NATO nations with two communications spacecraft positioned near 20 degrees W. longitude in synchronous, near equatorial orbits. The AFSCF is required to provide and conduct all telemetry, command and spacecraft

control functions during each operational phase, *i.e.*, transfer orbit, drift orbit (station acquisition), and final orbit (stationkeeping) for the life of the system.

152. The NATO II spacecraft attitude control systems, and the AFSCF procedures and operations controlling the NATO II spacecraft attitude maneuvers, are structurally and functionally equivalent to the corresponding Skynet II system and its AFSCF procedures and operations in the manner of operation, purpose and result, differing only in immaterial details.

DSCS II System Details

153. The DSCS II spacecraft furnishes the U.S. National Communications System and the military services with a high capacity, secure, strategic communications satellite network. The DSCS II spacecraft are launched in pairs into synchronous (19,300 nautical mi.) orbits on a Titan III-C booster.

154. The AFSCF is responsible for all telemetry tracking and control of the DSCS II spacecraft systems throughout the system's lifetime. The AFSCF procedures and operations controlling the DSCS II spacecraft attitude maneuvers are structurally and functionally equivalent to the corresponding Skynet II AFSCF procedures and operations in the manner of operation, purpose and result, differing only in immaterial details.

155. The DSCS II spacecraft attitude control systems are generally structurally and functionally equivalent to the corresponding Skynet II spacecraft systems in the manner of operation, purpose and result, except that there are these three differences: (i) the DSCS II axial thrusters are canted at a 45 degree

angle to the spin axis and thus expel the thruster gases at an angle of 45' to the spin axis, instead of parallel to the spacecraft's spin axis; (ii) the DSCS II spacecraft sun sensor is physically mounted on the spacecraft's narrow beam communications antennas which are in turn mounted on the despun (nonspinning) portion of the spacecraft. The sun sensors were only to provide information regarding the accuracy of the orientation of the narrow beam communications antenna, but proved not to be appropriate for this purpose; and (iii) the DSCS II spacecraft spin axis attitude determinations are achieved by using multiple earth sensors equipped to measure accurately the "earth-chord length" along two different lines of sight. The leading edge of a chord-length signal was used as a longitude reference, corresponding to the "sun pulse" employed for that purpose in the NATO II and Skynet II spacecraft.

Comparison With Claims of Williams

156. Claim 1 of Williams requires (1) means for providing an indication of the ISA to an external location, and (2) means for pulsing the precession jet within a fixed time period after the receipt of the control signal. Neither of these two claimed elements can be shown in the structure of the accused Skynet II, NATO II and DSCS II systems. Therefore, as claims 2 and 3 of Williams also include this subject matter, it is clear that the claims of Williams do not literally read on the structure of these satellites.

IMP (H and J) System Details

157. In November of 1963, the National Aeronautics and Space Administration (NASA) began launching a series of 10 spacecraft, known as

Interplanetary Monitoring Platforms (IMPs), to study and monitor the plasmas, magnetic fields, and energetic particle populations of interplanetary space. The 10 IMP spacecraft were designated IMP-A through IMP-J. The last two spacecraft of this series, IMPs-H and-J (hereinafter referred to simply as IMPS) incorporate attitude control systems (ACSS) which plaintiff alleges to infringe the Williams patent, No. 3,758,051.

158. IMP-H was launched on September 22, 1972, and IMP-J was launched on October 25, 1973. Both were placed into a high, circular 130,000 mi. earth orbit about halfway to the moon.

159. Goddard Space Flight Center (GSFC) in Greenbelt, Maryland, in conjunction with its world-wide Spacecraft Tracking and Data Acquisition Network (STADAN), provides ground support functions for the IMP missions. There are approximately 10 STADAN stations located around the earth on both U.S. and foreign soil. The ground support functions of the STADAN stations include telemetry data acquisition, tracking, and commanding. All communication to and from the IMP spacecraft are performed through the STADAN station that was in contact with the spacecraft at the time of transmission. Telemetry received by a STADAN station from an IMP spacecraft was transmitted to GSFC where it was reduced to a usable form. All commands to IMP spacecraft originated at GSFC and were transmitted to the spacecraft through the appropriate STADAN station.

160. The IMPs-H and-J had similar mechanical configurations, each comprising a 16-sided drum with the majority of the outer surface of the drum being

covered with solar cells. Two attitude control booms extended radially outwardly from the drum.

161. The IMP spacecraft were spin-stabilized vehicles having gyroscopic properties. An attitude control system employing pulsed jets was used to adjust the orientation of the spin axis of the vehicles while in orbit. The structure and operation of the attitude control systems on IMPs-H and-J were substantially the same. A cold gas propellant, Freon-14, stored on board the IMP spacecraft was coupled through appropriate plumbing to valve-controlled orientation jets located on the ACS booms at a moment arm distance from the spacecraft center of mass. Two orientation jets were available for attitude maneuvers, each located on an ACS boom 180 degrees from the other, and directed parallel to the spin axis. The two orientation jets were actuated simultaneously, each contributing one-half of the torque.

162. The IMP attitude control system was only capable of precessing the spin axis of the spacecraft in one of the four cardinal directions: north, east, south, or west. These directions are all measured relative to a celestial sphere centered on the spacecraft wherein the sun is the north reference. North-south maneuvers were in the sun plane, which is that plane formed by the sun and the spin axis. East-west maneuvers were in a plane perpendicular to the sun plane. Because of the limited number of precession directions available, a series of successive commands ordering precession in different directions would be necessary for some attitude changes.

163. The IMP attitude control system includes an optical aspect system which has an earth telescope and a solar sensor. The parameters measured by the

optical aspect system are (1) the spin period of the spacecraft, (2) sun time, (3) earth time, (4) earth width, and (5) spin axis sun angle. The solar sensor also produced a "solar command pulse" each revolution when the sun crossed its field of view. An onboard clock (called the "spacecraft encoder") samples the optical aspect data once every C 24 period where the C 24 period is equal to 81.92 seconds. The leading edge of the C 24 period is used as a signal to start collecting the aspect data. The spin period is simply the time it takes for the satellite to make a single revolution. The sun time is the interval between the beginning of the C 24 period and the next sun pulse. The earth time is the interval between the sun pulse and the earth pulse that defines the start of an earth scan. The earth width is the interval between the first earth pulse and the second earth pulse, corresponding to the apparent width of the earth. This information is telemetered to ground at the end of each C 24 period, every 81.92 seconds.

164. This aspect data is used on the ground to determine the orientation of the spin axis in a fixed external coordinate system.

165. The C 24, 81.92 second time period is a time standard known on the ground and on the satellite. This means that the absolute time at which the C 24 period starts and stops is known, or at least knowable, on the ground. As the sun time is defined relative to C 24, the time of the sun pulse is known on the ground. Knowledge of the spin rate and the time at which the sun pulse occurs is sufficient information to determine the instantaneous spin angle position. (*See* findings 34 and 39.) Thus, the IMP spacecraft provides the ground with an indication of the ISA.

166. Although information from which the ISA could be calculated is provided to the ground (*see* finding 165), it is not clear from the record whether the ISA is ever actually calculated. The information is apparently used in analyzing data from the experiments.

167. Once the attitude of the spacecraft was determined, a decision regarding an attitude correction maneuver could be made. Attitude maneuvers involved a sequence of three ground commands to the spacecraft. The first command reset the logic circuitry in the ACS electronics on board the IMP spacecraft. The second command, called the Orient command, indicated the direction, either north, east, south, or west (*see* finding 162) of the desired precession. The Orient command @l not indicate a specific time delay for pulsing the orientation jets. Instead, said Orient command in effect programmed the onboard ACS electronics to select an appropriate time delay generated by onboard timing circuitry so as to accomplish precession in the commanded direction. The Orient command did not itself initiate precession. A third ground command, referred to as the ACS On Command, was required to initiate the sequence whereby propellant was expelled from the jets to cause precession to occur in the direction selected by the Orient command and at the time computed by the onboard circuitry.

168. No calculation of the time of occurrence of any spin event on board an IMP spacecraft was required, or in fact performed, by the ground control in initiating any ACS command. No knowledge of the instantaneous spin angle position of the spacecraft was required or used by the ground control to generate an

ACS command. No ACS command transmitted from the ground was in any way synchronized with or in any time critical relationship to, the instantaneous spin angle position of the spacecraft orientation jets as they revolved about the spin axis.

169. Although the desired direction of precession was selected by the ground control, the actual timing for pulsing the orientation jets to achieve precession in the selected direction was developed entirely on board the IMP spacecraft. There was no way that these orientation jets could be operated instantaneously or at the end of a fixed time period (*i.e.*, in "real time") by the ACS commands upon their receipt at the spacecraft from the ground. The basic timing mechanism was an onboard digital system that generated a time-based clock signal synchronized with the occurrence of the "solar command pulse (*see* finding 163) and, hence, with the spin rate. The clock, in effect, electronically divided the spin period into a number of equal time intervals. The first interval corresponded to the occurrence of the solar command pulse and served as a reference instantaneous pointing direction of a point on the spacecraft.

170. Logic circuitry in the onboard ACS electronics utilized the clock signal to produce tour cardinal direction synchronized pulses during each revolution. Said pulses were one-sixteenth (1/16) of a revolution in duration and spaced 90 degrees apart. The pulse spacing and durations were fixed angular values. The actual time duration of and between pulses was related to the spin rate of the spacecraft. The onboard clock and ACS electronics, in effect, performed the computations to convert the fixed angular value to times. This timing was not per-

formed on the ground and was not contained in any ACS ground-generated command.

171. Each synchronous pulse corresponded to one of the cardinal directions of north, east, south, or west, wherein the direction toward the sun represented north. That is, the synchronous pulses were timed by the onboard electronics to occur during the course of each revolution, such that if the orientation jet were activated during the occurrence of one of the synchronous pulses, the spacecraft would precess in the direction to which the synchronous pulse corresponded. The four synchronous pulses corresponding to the four cardinal directions were generated each revolution. These pulses were repetitively present at a respective logic gate whether or not they were used by the system to activate the orientation jets.

172. The effect of an Orient command transmitted from the ground was to enable (*i.e.*, open) the logic gate corresponding to the desired direction of precession. The enabled gate allowed the synchronous pulses at its input to pass through to another gate called the Orient Enable Gate. No precession would occur, however, until after the ground-generated ACS On command was received.

173. The first "solar command pulse" (*see* finding 163) following receipt of the ACS On command enabled the Orient Enable Gate. This allowed the synchronous direction pulses passing through the logic gate selected by the Orient command to actuate the orientation jets causing precession in the desired direction. The occurrence of the solar command pulse was a nonsynchronous event with respect to the receipt of the ACS On command. The only reason for waiting for the first solar command pulse was to

eliminate the possibility of actuating the orientation jets for less that 1/16 of a revolution. That is, if it were not for this provision, the Orient Enable Gate would be enabled immediately upon receipt of the ACS On command, and this could occur in the middle of the chosen synchronous pulse. Synchronous pulses generated on board, rather than from the ground, continued to actuate the orientation jet once each revolution for eight revolutions, at which time the Orient Enable Gate was disabled by appropriate logic circuitry. Further precession in the same or one of the other three cardinal directions required the same sequence of the ACS ground commands.

Comparison With Claims of Williams

174. The claims of the Williams patent require means for pulsing the precession jet within a fixed time period after receipt of a control signal. (*See* findings 116 and 121.) There is no corresponding means in the accuse IMP (H and J) system, and thus the claims do not literally read on the system.

Pioneer "Programmed" (Store-and-Execute) Mode

Pioneer System Details

175. Pioneer 10 and 11, unlike the other accused spacecraft, are not satellites. These spacecraft were designed to explore our solar system, and in particular to investigate the interplanetary medium, the nature of the Asteroid Belt, and the environmental and atmospheric characteristics of the planet Jupiter. For the purposes of this case, the two spacecraft (Pioneer 10 and 11) can be considered as being identi-

cal. Hereinafter, a reference to "Pioneer" includes both spacecraft.

176. Like all the other accused spacecraft, Pioneer is spin stabilized. Pioneer basically has three attitude control modes: automatic (called "Conscan"), programmed precession, and real time. All of these modes use a precession jet offset from the spin axis and pulsed at the appropriate time of the spin cycle in order to change orientation. The automatic mode, "Conscan" (conical scan), acts to maintain the spin axis pointed in the direction of an r.f. (radio frequency) signal emanating from the earth. This automatic mode is similar to the automatic attitude control system of the McLean patent in that both act to automatically align the spin axis with a target. The plaintiff makes no argument that this mode infringes any of the claims of Williams.

177. Each Pioneer vehicle carries a directional radio antenna responsive to electromagnetic radiation transmitted from earth to the spacecraft, plus a sun sensor and a star sensor. Data, derived from these spacecraft components and telemetered to earth, contains information from which the vehicle's attitude, its spin rate, and its instantaneous spin angle position can be determined. In the programmed mode, the only use for the data which provides an indication of the ISA is in analyzing the scientific data collected by the spacecraft.

178. To keep a Pioneer vehicle on its proper course, it was necessary from time to time to make changes in velocity, or direction, or both. Such course and speed changes had to be accomplished by firing an onboard rocket motor in a precisely determined direction; hence, each such maneuver

included (i) a temporary attitude change for proper orientation of the rocket motor, and (ii) a re-adjustment of the vehicle attitude or orientation after the desired course or speed correction, to bring the spacecraft's radio beam back into line with the earth.

179. Although precession of the spin axis away from an earth-pointing orientation was not designed into Pioneer's "automatic" attitude control mode, the attitude maneuvers required for course correction could be carried out by operating the system in its "Programmed" mode, which is similar to the "store-and-execute" mode used in the Skynet II, NATO II, and DSCS II communications satellite systems. The commands required for a desired Pioneer attitude maneuver were calculated on the ground, using in part certain telemetered data from the spacecraft. The appropriate orientation commands were then transmitted to the Pioneer spacecraft by radio for initial storage in the onboard memory, being later decoded and used by onboard program execute circuits in the control of the precession jet valve after an "execute" command had been transmitted from the earth at some subsequent time.

180. In particular, however, Pioneer's "Programmed" mode did not utilize the instantaneous spacecraft spin angle position at ground locations to generate orientation command control signals for recessing the spacecraft. These precessing orientation (attitude) control signals transmitted by the ground to the Pioneer spacecraft in the "programmed" mode were not synchronized with, or in a fixed temporal relation with, the instantaneous spin angle position of the spacecraft.

181. Also in the Pioneer "programmed" mode, the firing of the spacecraft precession jet after receipt of the execute command was not time related to the time when the spacecraft received these precession control commands. Thus, the firing of the precession jet was not executed immediately upon receipt by the Pioneer spacecraft of the "programmed" mode recessing orientation command or execute signals. Nor was the jet fired at the end of any fixed invariable time interval following receipt of such commands or execute signals. In the Pioneer "programmed" mode, the precise time of firing the precession jet was subsequently determined by the spacecraft itself after it had first received and stored the orientation commands, and after receipt of the "execute" command.

Comparison With Claims of Williams

182. The claims of the Williams patent require means for pulsing the precession jet within a fixed time period after receipt of a control signal. (*See* findings 116 and 121.) There is no corresponding means in the accused "programmed" mode of the Pioneer (10 and 11) system.

Plaintiff's Argument

183. Plaintiff has conceded that the claims of the Williams patent do not literally read on the accused "store-and-execute" systems. This fact is made clear by a review of the plaintiff's comments made in the posttrial papers.

> Plaintiff does not contend that the claims in suit read literally on the Skynet II, NATO II and DSCS II spacecraft, plaintiff's claim of infringe-

> ment being based on the equivalency of those systems to the claimed subject matter.

Plaintiff's objections to Defendant's Requested Findings of Fact, p. 38, objection to findings 382-85.

> 95. The court finds that the satellites of the "store and execute" group—NATO II, Skynet II, DSCS II and IMP—while not falling within the literal terms of the claims of the Williams patent, utilize the Williams invention.
>
> * * * * *
>
> 97. The court also finds that the Pioneer satellites, embodying "store and execute" * * * attitude control systems, constitute a use of the Williams invention for the same reasons set forth in * * * [finding] 95 * * *.

Plaintiff's Proposed Findings of Fact, findings 95 and 97.

> Such facts establish that the "store and execute" satellites do infringe the Williams patent by virtue of the doctrine of equivalence, even though the claims of the patent do not literally "read" on the accused systems.

Plaintiff's Post-Trial Brief, p. 40.

> The Government leads off * * * with a long argument addressed to a point not in dispute-namely, that the claims of the patent in suit do not literally "read" on the store-and-execute spacecraft.

Plaintiff's Post-Trial Reply Brief, p. 4.

File Wrapper Estoppel and the Doctrine of Equivalents

184. Just prior to the citation of McLean, the plaintiff still had claims 3, 5 and 8-14 in the case. These claims were directed broadly to controlled precession of a spinning body using an offset precession jet pulsed synchronously with the spin of the body. In response to the citation of McLean, plaintiff cancelled claims 3, 5 and 8-14 and added three new claims which are now patent claims 1-3. Each of these claims recited the two elements discussed in finding 155. These elements had not been previously claimed in claims 3, 5 and 8-14.

185. The first element is the means for providing an indication of the ISA to an location. Skynet II, NATO II, and DSCS 11 do not have such a means. (*See* finding 155.) The second element is the means for applying fluid to said fluid expulsion means (the precession jet) within a fixed time period after the receipt of a control signal. None of the accused store-and-execute spacecraft have such a means. (*See* findings 155, 174 and 182.) These elements were added in combination with a number of other elements to overcome the prior art cited.

The Real Time Systems

Solrad (9 and 10)

186. The Solrad satellites, launched by NASA for the Naval Research Laboratory, were spin-stabilized satellites in low altitude earth orbits and used to monitor solar radiation. Solrad 10 (launched July 8, 1971, was kept oriented with its spin axis aligned with the sun line so as always to point toward the sun.

Solrad 9 (launched March 5, 1968) was kept oriented with its spin axis always perpendicular to the sun line. Each was equipped with an attitude control system capable of functioning in two modes.

187. One Solrad mode, not here accused of infringing the patent in suit, was an it automatic mode" in which the precessing signal was generated on board, without any radio contact with earth.

188. The automatic attitude control system included a precession jet disposed on the satellite such that it was spaced from the spin axis and oriented to expel gas substantially along a line parallel to the spin axis. Sun sensors positioned on the satellite provided an indication of the ISA with respect to the sun and an indication of the sun angle (the angle between the spin axis and the sun vector). When the satellite deviated from its selected orientation with respect to the sun (perpendicular for Solrad 9 and aligned for Solrad 10) the information provided by the sun sensors was automatically used to pulse the precession jet during the proper portion of the spin cycle so that the satellite was precessed back into its desired orientation.

189. Although each of the Solrad 9 and 10 satellites transmitted its instantaneous spin angle position to ground for purposes of processing and interpreting certain scientific data collected by other sensors on board, this was not done for the purposes of sending back a precession jet command signal to the satellite's attitude control circuits.

190. In the construction of the Solrad 9 and 10 satellites at the Naval Research Laboratory, a circuit was added to each for permitting its precession jet

valve to be directly operated by an externally applied signal while the satellite was undergoing prelaunch tests in a vacuum chamber where no sun source was available, the purpose here being so that NRL personnel could easily open and close said precession jet valve while the satellite was in said chamber in order to make sure that this valve was working properly. After these ground tests had been concluded, it was decided to leave said circuit in each satellite to provide a real time backup mode for turning on the precession jet valve by a signal from the Solrad ground station in the event that the satellite's attitude control system sun sensors failed while the satellite was in earth orbit.

191. A fine angle sun sensor provided an indication of the instantaneous spin angle position and the angle of the spin axis with respect to the sun vector. This information was relayed to the ground. Normally, this was used to help in interpreting scientific data but in the case of failure of other sun sensors, this information could be used to determine when a signal to pulse the precession jet should be sent in order to restore the proper orientation.

192. Ground control has had at all times the capability of pulsing the jet directly from the ground. However, in order to send a pulse that will activate the jet at the proper time in the spin cycle, some equipment must be provided to do a job similar to that done by the apparatus of Fig. 12 of the Williams patent. As the automatic attitude correction system has never failed, the necessary equipment has never been built.

Comparison With Claims of Williams

193. Claim 1 of Williams requires:

1. Apparatus comprising:

a. a body adopted to spin about an axis;

The Solrad satellites were spin stabilized.

Additionally, claim 1 recites:

b. fluid supply means associated with said body;

c. a valve connected to said fluid supply means;

d. fluid expulsion means disposed on said body and coupled with said valve and oriented to expel said fluid substantially along a line parallel to said axis and separated therefrom; * * *.

The Solrad satellites each had a nozzle oriented parallel to the spin axis and connected through a valve to a tank of gas.

Clause "e" of claim 1 calls for:

> [M]eans disposed on said body for providing an indication to a location external to said body of the instantaneous spin angle position of said body about said axis and the orientation of said axis with reference to a fixed external coordinate system; * * *.

The Solrad satellites each provided an indication of the ISA with respect to the sun (a fixed point in a

fixed external coordinate system) to the ground control for purposes of processing the scientific data. This ISA indication was provided by a fine angle sensor independently of the sun sensors used for the automatic orientation mode. It was contemplated that if the orientation sun sensors failed the ISA used for experiments could have been used to provide the needed synchronization to operate in the real time mode. The Solrad satellites also provided an indication of the orientation of the spin axis in a fixed external coordinate system.

Finally, claim 1 requires:

> f. and means disposed on said body for receiving from said location control signals synchronized with said indication;
>
> g. said valve being coupled to said last-named means and responsive to said control signals for applying fluid to said fluid expulsion means in synchronism therewith for precessing said body to orient said axis in a predetermined desired relationship with said fixed external coordinate system.

Both Solrad satellites had a circuit which permitted the precession jet valve to be directly operated by a signal from ground control.

194. Claims 2 and 3 of Williams incorporate substantially all of the subject matter of claim 1 along with some additional limitations. The only significant added limitations are that claim 2 requires "wide angle means" and claim 3 requires "wide angle optical

means" for providing the ISA and orientation indications. Although each of the Solrad satellites had wide angle optical sun sensors, there is no indication from the record that these sensors were intended to be or could be used to provide indications of the ISA and orientation in a real time backup mode. The fine angle sensors referred to above have a field of view of about 10 degrees.

195. In view of the above findings, it is clear that claim 1 of Williams reads on the structure of the Solrad 9 and 10 satellites.

The Real Time Mode of Pioneer (10 and 11)

196. As discussed in finding 176, the Pioneer spacecraft (10 and 11) have three attitude control modes. The real time mode was designed as a backup system to be used in case of failure of one or more of the primary attitude control systems. Like Solrad, this system includes a circuit which can be activated by a signal from the ground. Upon receipt of the signal, the precession jet is immediately pulsed. There has never been a need to use this backup circuit. It is clear, however, that a number of different uses were contemplated based on the various possible failures that could be envisioned. At least one of these contemplated modes of uses involved determining the ISA and orientation of the spacecraft with respect to a fixed external coordinate system on the ground from indications provided by the spacecraft.

197. In order to properly precess the spacecraft in this mode, the signal sent to activate the precession jet circuit must be sent in synchronism with the ISA. In order to do this, the ground control must be provided with equipment capable of performing the

synchronizing function. (*See*, for example, Fig. 12 of Williams.) This equipment has never been built because the primary systems have all continued to function properly.

Comparison With Claims of Williams

198. Claim 1 of Williams calls for:

1. Apparatus comprising:

a. a body adapted to spin about an axis; * * *.

The Pioneer spacecraft is spin stabilized.

In addition, the claim also requires:

b. fluid supply means associated with said body;

c. a valve connected to said fluid supply means;

d. fluid expulsion means disposed on said body and coupled with said valve and oriented to expel said fluid substantially along a line parallel to said axis and separated therefrom; * * *.

Pioneer has a nozzle oriented parallel to the spin axis and connected through a valve to a gas supply tank.

Clause "e" of the claim provides:

> [M]eans disposed on said body for providingan indication to a location external to said body of the instantaneous spin angle position of said body about said axis and the orientation of said axis with refer-

ence to a fixed external coordinate system.

The sun sensor provides an indication to ground control of the ISA with respect to the sun. The orientation of the spin axis with respect to a fixed coordinate system can be determined from the telemetered Conscan phase and amplitude data. The Conscan system uses a medium gain directional antenna, offset from the spin axis by about 9.3 degrees. As the r.f. (radio frequency) signal from earth is received by the antenna, the Conscan system generates amplitude and phase data which is relayed to earth. This data indicates the degree to which the spin axis is out of alignment with the earth. When this data indicates that the spin axis is pointing at the earth, the orientation of the spin axis in a fixed coordinate system is known.

The Pioneer Program document No. PC202 suggests on p. 5-3 that even if the Conscan function fails the Conscan telemetry of phase and amplitude data might remain. If, however, the Conscan telemetry has failed as well, document No. PC202 suggests that the orientation can be determined by dead reckoning using the time that Conscan last indicated that the spin axis was pointing at the earth, the rate of change of orientation in inertial space of the spacecraft-earth line, and the magnitude and direction of solar torques acting on the spacecraft.

Finally, claim 1 calls for:

f. and means disposed on said body for receiving from said location control signals synchronized with said indication;

g. said valve being coupled to said last-named means and responsive to said control signals for applying fluid to said fluid expulsion means in synchronism therewith for precessing said body to orient said axis in a predetermined desired relationship with said fixed external coordinate system.

The Pioneer spacecraft each have a circuit which acts to pulse the precession jet immediately upon receipt of a control signal. Thus, claim 1 reads on the structure of Pioneer 10 and II.

199. Claims 2 and 3 of Williams incorporate substantially all of the subject matter of claim-1 along with some additional limitations. The significant added limitations are that claim 2 requires "wide angle means" and claim requires "wide angle optical means" for providing the ISA and orientation indications. Pioneer's sun sensor covers a field of view of 170 degrees. This is clearly wide angle and optical. However, this sensor provides no indication o the sun angle (the angle between the spin axis and the line from the sun to the spacecraft).

200. The orientation is determined by the medium gain Conscan antenna. This antenna determines pointing errors of up to only about 10 degrees. The "field of view" of this antenna then is about 20 degrees. Although the term "wide angle" does not provide a clear cutoff, some guidance on the question of how wide the angle must be can be obtained from plaintiff's arguments made in distinguishing McLean on this basis. The field of view of the sensor of McLean is about 8 degrees to 10 degrees. Plaintiff

argued that this is not a wide angle in the sense of the claims, pointing out that the solar sensor of Williams has a field of view of 140 degrees. Although it is still not clear where the cutoff between the wide angle and narrow or medium angles is, it is clear that 20 degrees is not a wide angle field of view.

201. The situation where the automatic earth pointing system (Conscan) failed completely while the sun sensor system still remained operational was contemplated. In such a situation, it would be desirable to maintain the spin axis in an earth pointing direction so that the communications link could be maintained. It was contemplated that this could be done by first determining the orientation using dead reckoning. This orientation would be in a coordinate system formed by the sun, the earth, and spacecraft. While this coordinate system is not a fixed external coordinate system, its relationship to a fixed external coordinate system is known. Thus, any orientation given in the sun-earth-spacecraft coordinate system is with reference to a fixed coordinate system.

202. Ground control would then determine at what point during the spin cycle a pulse need be provided to provide precession in the proper direction. This pulse would then be synchronized with the sun pulse and sent up to activate the precession jet. Because the reference pulse (sun pulse) is not coming from the target (the earth), it is necessary to the formulation of the proper control pulse to know the orientation of the spin axis in a fixed external coordinate system. Thus, in at least one of the contemplated modes of using the real time pulsing circuit, the Pioneer spacecraft was intended to do the same work, in sub-

stantially the same way and accomplish substantially the same result as in Williams.

203. Defendant argues that the only contemplated mode of operating the real time emergency backup attitude control system was by trial and error. It is clear, however, from the record that this method would only be used if the sun pulses were not available. If they are available, it only makes sense to use them. This contingency was clearly contemplated by those considering the possible ways in which the real time circuit could be used.

CONCLUSION OF LAW

Upon the foregoing findings of fact, which are made a part of the judgment herein, the court concludes as a matter of law that claims 1, 2 and 3 of United States Letters Patent No. 3,758,051 are valid and enforceable. Further, it is concluded that the accused Solrad (9 and 10) and Pioneer (10 and 11) systems have been used and/or manufactured by or for the defendant without authorization or license from the plaintiff and infringe claim 1. Therefore, plaintiff is entitled to recover reasonable and entire compensation, and judgment is entered to that effect. The amount of recovery will be determined pursuant to Rule 131 (c)(2).

Additionally, the court concludes that claims 2 and 3 are not infringed by the Solrad (9 and 10) or the Pioneer (10 and 11) systems, and that claims 1, 2 and 3 are not infringed by any of the accused Skynet II, NATO II, DSCS II, or IMP (H and J) systems.

APPENDIX E

UNITED STATES COURT OF APPEALS
FOR THE FEDERAL CIRCUIT

94-5149, 95-5001
CFC 426-73

HUGHES AIRCRAFT COMPANY,
PLAINTIFF-APPELLANT

v.

THE UNITED STATES, DEFENDANT
CROSS-APPELLANT

[Filed Oct. 17, 1996]

ORDER

A combined petition for rehearing and suggestion for rehearing in banc having been filed by the CROSS-APPELLANT, and a response thereto having been invited by the court and filed by the APPELLANT, and the petition for rehearing having been referred to the panel that heard the appeal, and thereafter the suggestion for rehearing in banc and response having been referred to the circuit judges who are in regular active service,

UPON CONSIDERATION THEREOF, it is

ORDERED that the petition for rehearing be, and the same hereby is, DENIED and it is further

ORDERED that the suggestion for rehearing in banc be, and the same hereby is, DECLINED.

The mandate of the court will issue on October 24, 1996.

FOR THE COURT,

MELVIN L. HALPER, ACTING CLERK

Dated: October 17, 1996

By /s/ BRIAN P. LEDUC
BRIAN P. LEDUC
Associate Chief Deputy Clerk

cc: Kenneth W. Starr
Thomas J. Byrnes

Note: Pursuant to Fed. Cir. R. 47.6, this order is not citable as precedent. It is a public record.